Date: 14/10/2021

Q1. The mass of one atom of hydrogen is 1.008 amu. What is the mass of 32 atoms of hydrogen? Express the result with correct number of significant figures.

Q2. How many significant figures should be present in the answer of the following calculations?

(a) $\dfrac{0.02856 \times 298.15 \times 0.112}{0.5785}$ (b) $0.0125 + 0.7864 + 0.0215$

Q3. Using exponential notation, express the number 582,000,000 to

(a) one significant figure (b) four significant figures

Q4. Round up the following upo three significant figures:

(a) 0.04597 (b) 2808

Q5. Express the following in the scientific notation:

(a) 0.0048 (b) 234.000 (c) 500.0 (d) 6.0012

Q6. Wavelength of a certain radiation was found to be 5732 Å. Express it in nm.

Q7. If the speed of light is 3.0×10^8 m s^{-1}. Calculate the distance covered by light in 2.00 ns.

Q8. Express the concentration 0.30 g/mL in kg/m^3.

Q9. Convert the following into basic units:

(a) 28.7 pm (b) 25365 mg

Q10. The density of vandium is 5.96 g cm^{-3}. Convert the density to SI units of kg m^{-3}.

Q11. Express the results of the following calculations to the appropriate number of significant figures:

(a) $\dfrac{(1.36 \times 10^{-4})(0.5)}{2.6}$ (b) $0.582 + 324.65$ (c) $2.64 \times 10^3 + 3.27 \times 10^2$

Q12. Express the following up to three significant places:

(a) the height of a man, 5 feet 9 inches in centimetres (1 inch = 2.54 cm)

Q13. Calculate the number of significant figure in the following values:

(a) Avogadro number (b) Electronic charge

Q14. A tennis ball was observed to travel at a speed of 96 miles per hour. Calculate the speed of the ball in metres per second.

Q15. Express the following in SI units: 150 pounds (this is the average weight of an Indian male).

Q16. Express the following in SI units: 0.74 Å (this is the bond length of hydrogen molecule).

Q17. Express the following in SI units: 93 million miles (this is the distance between the Earth and the Sun).

Q18. A jug contains 2 L of milk. Calculate the volume of milk in m^3.

Q19. Convert the following:

(a) 40 Em (exametre) (thickness of Milky way galaxy) into metre

(b) 1.4 Gm (gigametre) (distance of nearest star) into metre

(c) 500 Mg (megagram) (mass of a loaded jumbo jet) into kilogram

Q20. Density of copper is 7.8 g cm^{-3} and its weight is 5.642 g. Report the volume of copper to correct decimal point.

Q21. What is the difference between 2.0 m and 2.00 m?

Date: 14/10/2021

S1. Mass of 32 atoms of hydogn = $32 \times 1.008 = 32.256$ amu. The number 32 is an exact number and has infinite number of significant figures. The number 1.008 has 4 significant figures. In multiplication and division, the result should contain the lower number of signicant figures. The avbove result is therefore rounded off to 4 signiicant figures. Hence the answer is **32.26 amu**.

S2. (a) The result should contain 3 significant figures.

(b) The answer is 0.8204. It contain 4 significant figures.

S3. (a) 6×10^8 (b) 5.820×10^8

S4. (a) 0.460 (b) 2810

S5. (a) 4.8×10^{-3} (b) 2.3×10^2 (c) 5.000×10^2 (d) 6.0012×10^0

S6. 573.2 nm

S7. Speed = Distance/Time

$\therefore$ Distance covered = Speed Time

$$= 3.0 \times 10^8\,\mathrm{m\,s^{-1}} \times 2.00\,\mathrm{ns}$$

$$= 3.0 \times 10^8\,\mathrm{m\,s^{-1}} \times 2.00 \times 10^{-9}\,\mathrm{s}$$

$$= \mathbf{6.0 \times 10^{-1}\,m}.$$

S8.

$$0.30\,\frac{\mathrm{g}}{\mathrm{mL}} = 0.30\,\frac{\mathrm{g}}{\mathrm{mL}} \times \frac{1\,\mathrm{kg}}{10^3\,\mathrm{g}} \times \frac{1000\,\mathrm{mL}}{1\,\mathrm{L}} \times \frac{1\,\mathrm{L}}{1\,\mathrm{dm}^3} \times \left(\frac{1\,\mathrm{dm}}{10^{-1}\,\mathrm{m}}\right)^3$$

$$= 0.30 \times 10^3\,\frac{\mathrm{kg}}{\mathrm{m}^3} = \mathbf{3.0 \times 10^2\,kg/m^3}.$$

S9. (a) $28.7\,\mathrm{pm} = 28.7 \times 10^{-12}\,\mathrm{m}$

(b) $$25365\,\mathrm{mg} = 25365\,\mathrm{mg} \times \frac{10^{-3}\,\mathrm{g}}{1\,\mathrm{mg}} \times \frac{1\,\mathrm{kg}}{10^3\,\mathrm{g}}$$

$$= 25365 \times 10^{-6}\,\mathrm{kg} = \mathbf{2.5365 \times 10^{-2}\,kg}.$$

S10. Density = $5.96\,\mathrm{g\,cm^{-3}}$

$$\therefore \quad 5.96\,\mathrm{g\,cm^{-3}} = \frac{5.96\,\cancel{\mathrm{g}}}{\cancel{\mathrm{cm}}^3} \times \frac{1\,\mathrm{kg}}{1000\,\cancel{\mathrm{g}}} \times \left(\frac{100\,\cancel{\mathrm{cm}}}{1\,\mathrm{m}}\right)^3$$

$$= 5.96 \times 10^3\,\mathrm{kg\,cm^{-3}} = \mathbf{5690\,kg/m^3}.$$

S11. (a) $$\frac{(1.36\times10^{-4})(0.5)}{2.6} = 0.2615\times10^{-4}$$

$$= \mathbf{0.3\times10^{-4}}$$

The answer should have one significant figure because 0.5 has one significant figure.

(b)
$$\begin{array}{r} 0.582 \\ +\ \ 324.65 \\ \hline 325.232 \end{array} = \mathbf{325.23} \quad \text{(Second place of decimal)}$$

Since 324.65 contains digits up to second place of decimal, therefore, the answer must be reported up to second place.

(c) $2.64\times10^3 + 3.27\times10^2$

or $2.64\times10^3 + 0.327\times10^3 = 2.967\times10^3 = \mathbf{2.97\times10^3}$

Since 2.64 has two digits after decimal place, the answer should be rounded off to two decimal places.

S12. (a) 5 ft 9 inch = 69 inch = 69×2.54 cm = 175.26 cm. With three significant figures answer is **175 cm**.

S13. (a) 6.023×10^{23} = 4 significant figures (b) 1.602×10^{-19} C = 4 significant figures.

S14. Speed of tennis ball = 96 miles per hour

$$1 \text{ mile} = 1.60 \text{ km} = 1.60\times10^3 \text{ m}$$

$$1 \text{ hr} = 60\times60 \text{ s} = 3.6\times10^3 \text{ s}$$

$$\text{Speed} = \frac{96\ \cancel{\text{mile}}}{\cancel{\text{hr}}}\times\frac{1.60\times10^3\text{ m}}{1\ \cancel{\text{mile}}}\times\frac{1\ \cancel{\text{hr}}}{3.6\times10^3\text{ s}} = \mathbf{42.7\ m\,s^{-1}}.$$

S15. $$1 \text{ pound} = 454\times10^{-3}\text{ kg}$$

$\therefore$ $$150 \text{ pound} = \frac{150\,(\cancel{\text{pound}})\times454\times10^{-3}\,(\text{kg})}{1\,(\cancel{\text{pound}})}$$

$$= 150\times454\times10^{-3}\text{ kg} = \mathbf{68.1\ kg}.$$

S16. $$1\text{ Å} = 10^{-10}\text{ m}$$

$$1\text{ Å} = 10^{-10}\text{ m}$$

S17. The SI unit of distance is metre (m)

$$1 \text{ mile} = 1.60 \text{ kilometre} = 1.60\times1000 \text{ m}$$

$\therefore$ $$93 \text{ million miles} = \frac{93\times10^6\ (\cancel{\text{miles}})\times1.6\times10^3(\text{m})}{1\ \cancel{\text{mile}}}$$

$$= 93\times1.6\times10^9\text{ m}$$

$$= \mathbf{148.8\times10^9 = 1.49\times10^{11}\ m}.$$

S18.

$$\text{Volume of milk} = 2\cancel{L} \times \left(\frac{1000\ \cancel{cm}^3}{1\cancel{L}}\right) \times \left(\frac{1\,m}{100\ \cancel{cm}}\right)^3$$

$$= \mathbf{2 \times 10^{-3}\ m^3}.$$

S19. (a) 1 Em (exametre) = 10^{18} m

$$\therefore \quad 40\ \text{Em} = 40\ \cancel{Em} \times \frac{10^{18}\ m}{1\ \cancel{Em}}$$

$$= \mathbf{4 \times 10^{19}\ m}.$$

(b) 1 Gm (gigametre) = 10^9 m

$$\therefore \quad 40\ \text{Gm} = 1.4 \times \cancel{Gm} \times \frac{10^9\ m}{1\ \cancel{Gm}}$$

$$= \mathbf{1.4 \times 10^9\ m}.$$

(c) 1 Mg (megagram) = 10^6 g and 1 kg = 1000 g

$$\therefore \quad 500\ \text{Mg} = 5\cancel{00}\ \cancel{Mg} \times \frac{10^6\ \cancel{g}}{1\ \cancel{Mg}} \times \frac{1\,kg}{10\cancel{00}\ \cancel{g}}$$

$$= \mathbf{5 \times 10^5\ kg}.$$

S20.

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{5.642\ g}{7.8\ g\ cm^{-3}}$$

$$= 0.7233\ cm^3 = 0.72\ cm^3$$

The result should have two significant figures because the least precise term (7.8) has two significant figures.

S21. They are scientifically different although they seems to be same. 2.0 m has two significant figures and hence its precision is 0.1 part in 2, *i.e.*, 50 ppt (parts per thousand). 2.00 m has three sinificant figures and its precision is 0.01 prts in 2, *i.e.*, 5 ppt. Hence, 2.00 m is more precise measurement than 2.0 m.

Date: 14/10/2021

Q1. If ten volumes of dihydrogen gas react with five volumes of dioxygen gas, how many volumes of water vapour would be produced?

Q2. Atomic weights of two isotopes of hydrogen are 1.0078 and 2.0143 respectively. Ordinary hydrogen contains these two isotopes in the proportion of 6400 and 1. What is the atomic weight of ordinary hydrogen?

Q3. In a chemical reaction 14 g of $NaHCO_3$ was allowed to react with 10 g of CH_3COOH. After the completion of the experiment only 16.67 g solution was left in the container. What was the mass of the gas which escaped into the atmosphere? Name the law applied.

Q4. Naturally occuring boron consists of two isotopes having atomic weights 10.01 and 11.01. The atomic weight of boron is 10.81. Calculate the percentage of each isotope in natural boron.

Q5. Carbondioxide contains 27.27% of carbon, carbondisulphide contains 15.79% of carbon and sulphurdioxide contains 50% of sulphur. Show that this is in agreement with law of reciprocal proportions.

Q6. Copper sulphide contains 66.6% Cu, copper oxide contains 79.9% copper and sulphur trioxide contains 40% sulphur. Show that these data illustrates law of reciprocal proportions.

Q7. Sulphur dioxide contains 50% sulphur, H_2S contains 5.88% hydrogen and water contains 88.89% oxygen. Show that the data explain the law of equivalent proportions.

Q8. In an experiment 34.5 g oxide of a metal was heated so that O_2 was liberated and 32.1 g of metal was obtained. In another experiment 119.5 g of another oxide of the same metal was heated and 103.9 g metal was obtained and O_2 was liberated. Calculate the mass of O_2 liberated in each experiment. Establish by calculation the law explained by the two calculations.

Q9. In an experiment of combustion 10 g H_2 was burnt in 100 g of O_2 so that 90 g H_2O was formed and 20 g of O_2 remained unreacted. In another experiment, when 18 g of H_2O was completely electrolysed, 2 g H_2 and 16 g O_2 were produced. Explain the law established by the two experiments.

Q10. Two oxides of a metal contain 27.6% and 30% of oxygen respectively. If the formula of the first compound is M_3O_4, find the formula of the second comopound.

Q11. Carbon and oxygen are known to form two compounds. The carbon content in one of these compounds is 42.9% while in the other, it is 27.3%. Show that the data are in the agreement with the law of multiple proportions.

Q12. If 6.3 g of $NaHCO_3$ are added to 15.0 g of CH_3COOH solution, the residue is found to weight 18.0 g. What is the mass of CO_2 released in the reaction?

Q13. The following data are obtained when dinitrogen and dioxygen react together to form different compounds:

Reaction	Mass of dinitrogen	Mass of dioxygen
(i)	14 g	16 g
(ii)	14 g	32 g
(iii)	28 g	32 g
(iv)	28 g	80 g

Which law of chemical combination is obeyed by the above experimental data? Give its statement.

Q14. In a chemical reaction 100 L N_2 was mixed with excess of H_2 but only 30 L of NH_3 was produced. Calculate (i) the volume of N_2 unused (ii) the volume of H_2 used in the reaction. Write the law or laws applied in the calculation.

Date: 14/10/2021

S1. Formation of water vapour from dihydrogen and dioxygen is given by

$2H_2(g)$	+	$O_2(g)$	$\longrightarrow$	$2H_2O(v)$
Dihydrogen		Dioxygen		Water
2 volumes		1 volume		2 volumes

Gay Lussac's law of combining volume gives.

2 volume of H_2 reacts with 1 volume of O_2 and gives 2 volumes of H_2O

$\therefore$ 10 volumes of H_2 reacts with 5 volumes of O_2 and gives 10 volumes of H_2O

S2. Atomic weight of ordinary hydrogen

= Average of atomic weights of isotopes present in oridinary hydrogen

$$= \frac{(1.0078 \times 6400) + (2.0143 \times 1)}{6400 + 1} = \mathbf{1.008}.$$

S3.

	$NaHCO_3(s)$	+	$CH_3COOH(l)$	$\longrightarrow$	$CH_3COONa(l)$	+	$H_2O(l)$	+	$CO_2(g)$
Initial	14 g		10 g		0		0		0
Final	0		0		16.67 g				x

According to the law of conservation of mass:

Initial mass before reaction = final mass after reaction.

$$14\text{ g} + 10\text{ g} = 16.67\text{ g} + x$$

$$\therefore \quad x = (14 + 10)\text{ g} - 16.67\text{ g} = 7.33\text{ g}$$

S4. Let the percentages of these isotopes in natural boron is x and $100 - x$ respectively. Since the atomic weight of an element is an average of atomic weights of isotopes, therefore

$$10.81 = \frac{10.01 \times x + 11.01 \times (100 - x)}{100}$$

$$\therefore \quad x = \mathbf{20\%}$$

and $\quad 100 - x = \mathbf{80\%}$

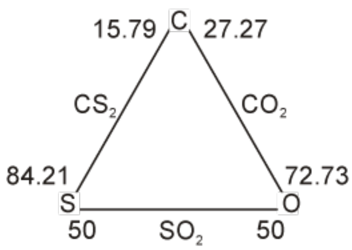
S5. **In CS_2**

C : S mass ratio is 15.79 : 84.21

15.79 parts of carbon combine with sulphur = 84.21

$\therefore$ 27.27 parts will combine with S

$$= \frac{84.21}{15.79} \times 27.27 = 145.434$$

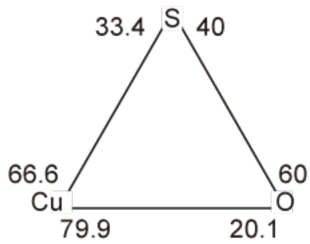


Hence, ratio of S : O is 145.434 : 72.73 *i.e.*, 2 : 1

In SO_2 the ratio of S : O is 1 : 1

Since, the ratio of S : O is a simpe whole number ratio, therefore law of reciprocal proportions is proved.

S6. **In copper sulpide:**



Cu : S mass ratio is 66.6 : 33.4

In sulphur trioxide:

O : S mass ratio is 60 : 40

Now in copper sulphide

33.4 parts of sulphur combines with Cu – 66.6 parts

40.0 parts of sulphur combines with Cu

$$= \frac{66.6 \times 40}{33.4} = \mathbf{79.8\ parts}.$$

Now, ratio of the masses of Cu and O which combine with same mass (40 parts) of sulphur separately is:

$$79.8 : 60 \qquad \text{... (I)}$$

Cu : O ratio by mass in CuO is:

$$79.9 : 20.1 \qquad \text{... (II)}$$

$$\text{Ratio I : Ratio II} = \frac{79.8}{60} \times \frac{20.1}{79.9} = 3 : 1$$

which is simple whole number ratio.

Hence, law of reciprocal proportion is proved.

S7.

$$\frac{\text{Mass of S in } SO_2}{\text{Mass of O in } SO_2} = \frac{50}{100 - 50} = \frac{50}{50} = \frac{1}{1}$$

$$\frac{\text{Mass of O in } H_2O}{\text{Mass of H in } H_2O} = \frac{88.89}{11.11} = \frac{8}{1}$$

$$\frac{\text{Mass of S in } H_2S}{\text{Mass of H in } H_2S} = \frac{94.12}{5.88} = \frac{16}{1}$$

We find that the mass ratio of S and O which combine with unit mass of H is two times the mass ratio in which S and O combine with one another. Therefore, the given data explain the law of equivalent proportions (law of reciprocal proportions).

S8.

$$\left.\begin{array}{l}\text{Mass of oxide} = 34.5\text{ g}\\ \text{Mass of metal} = 32.1\text{ g}\end{array}\right\} \qquad \text{... experiment 1}$$

$\therefore$ Mass of oxygen = 34.5 g – 32.1 g = 2.4 g

$$\frac{\text{Mass of metal combined}}{\text{Mass of oxygen combined}} = \frac{32.1\text{ g}}{2.4\text{ g}} = 13.375$$

$$\left.\begin{array}{l}\text{Mass of oxide } = 119.5\text{ g}\\ \text{Mass of metal} = 103.9\text{ g}\end{array}\right\} \quad \text{... experiment 2}$$

$\therefore$ Mass of oxygen = 119.5 g – 103.9 g = 15.6 g

$$\frac{\text{Mass of metal per unit mass of O in first oxide}}{\text{Mass of metal per unit mass of O in second oxide}} = \frac{13.375}{6.66} = \frac{2}{1}$$

The masses of metals which combine with the same mass of oxygen to form two compounds are in the ratio 2 : 1. This ratio is simple and thus the law of multiple proportions is established.

S9.

$2H_2$	+	O_2	$\longrightarrow$	$2H_2O$	... experiment 1
4 g		32 g		36 g	
10 g		x		90 g	

According to the law of conservation of mass

Mass of O_2 combined = Mass of H_2O formed – Mass of H_2 combined

= 90 g – 10 g = 80 g

Mass ratio of H and O in H_2O = 10 g : 80 g = 1 : 8

$2H_2O$	$\longrightarrow$	$2H_2$	+	O_2	... experiment 2
18 g		0		0	... start
10 g		x		90 g	... final

$$\frac{\text{Mass of } H_2 \text{ produced}}{\text{Mass of } O_2 \text{ produced}} = \frac{2\text{g}}{16\text{g}} = \frac{1}{8}$$

These two experiments establish the law of definite proportion and the law of constant composition.

S10. **First oxide** — **Second oxide**

First oxide	Second oxide
Oxygen = 27.6%	Oxygen = 30%
Metal = 72.4%	Metal = 70%

Formula of first oxide = M_3O_4

Let the atomic weight of metal = x

Percentage of metal in the compound $M_3O_4 = \frac{3x}{3x+64} \times 100$

$\therefore$ $$\frac{3x}{3x+64} \times 100 = 72.4$$

or $300x = 217.2x + 4633.6$

or $82.8x = 4633.6$ or $x = 56$

Now in the second oxide, metal and oxygen are 70% and 30%. Therefore, their atomic ratio will be

$$M : O$$

$$\frac{70}{56} : \frac{30}{16}$$

$$1.25 : 1.875$$

or $$1 : 1.5$$

or $$2 : 3$$

Therefore, formula of the compound = $\mathbf{M_2O_3}$.

S11. **In the first compound:**

Mass of carbon = 42.9 g

Mass of oxygen = 100 – 42.9 = 57.1 g

In the second compound:

Mass of carbon = 27.3 g

Mass of oxygen = 100 – 27.3 = 72.7 g

In the first compound:

Mass of carbon combining with 57.1 g of oxygen

= 42.9 g

Mass of carbon combining with 1.0 g of oxygen

$$= \frac{42.9\text{ g}}{57.1} = 0.75\text{ g}$$

In the second compound:

Mass of carbon combining with 72.7 g of oxygen

= 27.3 g

Mass of carbon combining with 1.0 g of oxygen

$$= \frac{27.3\text{ g}}{72.7} = 0.375\text{ g}$$

The ratio of mass of carbon combining with fixed mass of oxygen (*i.e.*, 1 g) is

0.75 : 0.375 or **2 : 1**

This is a simple ratio and therefore, illustrates the **law of multiple proportions**.

S12.

$$\underset{6.3\text{ g}}{NaHCO_3} + \underset{15.0\text{ g}}{CH_3COOH} \longrightarrow \underbrace{CH_3COONa + H_2O}_{\substack{\text{Rasidue} \\ 18.0\text{ g}}} + \underset{xg}{CO_2}$$

Sum of the mass of reactants = Mass of $NaHCO_3$ + mass of CH_3COOH

= 6.3 + 15.0 = 21.3 g

Sum of the mass of products = Mass of residue + Mass of CO_2 = $(18.0 + x)$ g

(where x is mass of CO_2 released)

According to law of conservation of mass

Mass of reactants = Mass of products

$$21.3 = 18.0 + x$$

or $$x = 21.3 - 18.0 = 3.3\,\text{g}$$

$\therefore$ Mass of CO_2 released = **3.3 g**.

S13. (i)

$$\underset{14\text{ g}}{\text{Dinitrogen}} + \underset{16\text{ g}}{\text{Dioxygen}} \longrightarrow \underset{30\text{ g}}{\text{Compound A}}$$

(ii)

$$\underset{14\text{ g}}{\text{Dinitrogen}} + \underset{32\text{ g}}{\text{Dioxygen}} \longrightarrow \underset{46\text{ g}}{\text{Compound B}}$$

Ratio of the masses of dioxgen which combine with fixed mass of dinitrogen (14 g) to form two different compounds A and B

$$= 16 : 32 = 1 : 2$$

Conclusion: The masses of dioxygen which combine separately with a fixed mass of dinitrogen bear a simple whole number ratio of 1 : 2. Therefore, the law of multiple proportions is obeyed by the given experimental data.

Similarly

(iii)

$$\underset{28\text{ g}}{\text{Dinitrogen}} + \underset{32\text{ g}}{\text{Dioxygen}} \longrightarrow \underset{60\text{ g}}{\text{Compound C}}$$

(iv)

$$\underset{28\text{ g}}{\text{Dinitrogen}} + \underset{80\text{ g}}{\text{Dioxygen}} \longrightarrow \underset{108\text{ g}}{\text{Compound D}}$$

Ratio of the masses of dioxygen which combine with 28 g of dinitrogen (fixed mass) to form two different compounds C and D.

$$= 32 : 80 = 2 : 5$$

Conclusion: The masses of dioxygen which combine separately with a fixed mass of dinitrogen bear a simple whole number ratio of 2 : 5. Therefore, the law of multiple proportions of obeyed by the given experimental data.A1.023 N

S14.

$$\underset{\substack{1\text{ Volume}\\ x}}{N_2} + \underset{\substack{3\text{ Volume}\\ y}}{3H_2(g)} \longrightarrow \underset{\substack{2\text{ Volume}\\ 30\text{ L}}}{2NH_3} \quad \text{... given}$$

According to Gay-Lussac's law of combining volumes

$$N_2 : H_2 : NH_3 = 1 : 3 : 2$$

$$\therefore \quad x : y : 30 = 1 : 3 : 2$$

$$\therefore \quad \frac{V(N_2)}{V(NH_3)} = \frac{1}{2}$$

$$\therefore \quad V(N_2) = \frac{1}{2} \times V(NH_3) = \frac{1}{2} \times 30\ L = 15\ L$$

Volume of N_2 unused = 100 L – 15 L = 85 L

$$\frac{V(H_2)}{V(NH_3)} = \frac{3}{2}$$

$$\therefore \quad V\ (H_2) = \frac{3}{2} \times V(NH_3) = \frac{3}{2} \times 30\ L = 45\ L$$

Date: 14/10/2021

Q1. Calculate the amount of N_2 atoms in 7 g of nitrogen gas. Given that:
$M(N) = 14\ g\,mol^{-1}$.

Q2. Calculate the amount of N_2 molecules in 7 g of nitrogen gas. Given that:
$M(N_2) = 28\ g\,mol^{-1}$.

Q3. Calculate the number of H_2O molecules in 9 g ofwater.
$M(H_2O) = 18\ g\,mol^{-1}$.

Q4. Calculate the amount (number of moles) of NH_3 in 59.5 g of ammonia.

Q5. The mass of 0.50 mole of a substance is 30 grams.Compute the molar mass of the substance.

Q6. Compute the mass of 10 moles of carbon dioxide (CO_2).
R.A.M.: C = 12, O = 16.

Q7. Find the mass of an atom silver. The molar mass of Ag atoms is 108 $g\,mol^{-1}$.

Q8. How many g atoms are there in one atom?

Q9. The ratio of the mass of a silver atom to the mass of a carbon atom is 9 : 1. Find the mass of one mole of silver atoms. Take the molar mass of C atoms 12 $g\,mol^{-1}$.

Q10. Chlorophyll contains 2.68% of magnesium by mass. Calculate the number of Mg atoms in 2.00 g of chlorophyll.

Q11. What is the molecular mass of a compound X, if its 3.0115×10^9 molecules weigh 1.0×10^{-12} g?

Q12. Calculate the residue obtained on strongly heating 2.76 g Ag_2CO_3.

Q13. The dot at the end of this sentence has a mass of about one microgram. Assuming that black stuff is carbon, calculate approximate atoms of carbon needed to make such a dot.

Q14. Calculate the number of Cl^- and Ca^{2+} ion in 222 g anhydrous $CaCl_2$.

Q15. From 200 mg of CO_2, 10^{21} molecules are removed. How many grams and moles of CO_2 are left.

Q16. How many years it would take to spend avogadro's number of rupees at the rate of 10 lakh rupees per second?

Q17. In three moles of ethane (C_2H_6), calculate the following:
(a) Number of moles of carbon atoms. (b) Number of moles of hydrogen atoms.
(c) Number of molecules of ethane.

Q18. Which one of the following will have largest number of atoms?
(a) 1 g Na(s) (b) 1 g Li_2(s)

Q19. Calculate the mass per cent of iron in haemoglobin ($C_{3032}H_{4740}O_{896}N_{760}S_{12}Fe_4$)
R.A.M: H = 1, C = 12, N = 14, O = 16, S = 32, Fe = 56

Q20. Find the mass percent of each element in sodium sulphate (Na_2SO_4), atomic masses: Na = 23 u, S = 32 u, O 16 u.

Q21. Compute the number of moles of N atoms in a sample of 192 g of TNT ($C_7H_5N_3O_6$).

Q22. Which one of the following will have largest number of atoms?
(a) 1 g Au (s) (b) 1 g of Cl_2(g)

Q23. Chlorophyll, the green colouring material of plants contains 2.68% of magnesium by mass. Calculate the number of magnesium atoms in 5.00 g of this complex.

Q24. Calculate mass of sodium which contains same number of atoms as are present in 4 g of calcium. Atomic masses of sodium amd calcium are 23 and 40 respectively.

Q25. How many molecules of water of hydration are present in 252 mg of oxalic acid, ($H_2C_2O_4 . 2H_2O$)?

Q26. How many atoms of oxygen are present in 300 g of $CaCO_3$?

Q27. Calculate number of molecules in each of the following:
(i) 14 g of nitrogen (ii) 3.4 g of hydrogen sulphide (H_2S)

Q28. Calculate mass of the following:
(i) one atom of calcium (ii) one molecule of sulphur dioxide (SO_2)

Q29. What is the volume of one molecule of water. (Density of H_2O = 1 g cm^{-3})

Q30. The volume of a drop of water is 0.04 mL. How many H_2O molecules are there in a drop of a water? (d = 1.0 g mL).

Q31. How many molecules of benzene (C_6H_6) are there in 1 L of benzene? Specific gravity of benzene is 0.88.

Q32. Calculate the number of atoms and volume of 1 g helium gas at S.T.P.

Q33. Find the number of g atoms and weight of an element haing 2×10^{23} atoms. Atomic mass of element is 32.

Q34. Haemoglobin contains 0.25% iron by weight. The molecular weight of haemoglobin is 89600. Calculate the number of iron atom per molecule of haemoglobin.

Q35. The molecular formula of Mohr's salt is $(NH_4)_2SO_4 . FeSO_4 . 6H_2O$
(a) Find the number of atoms of each element.
(b) Calculate the mass percentage of each element.
(c) What is the mass per cent of water of hydration in Mohr's salt?

Q36. Calculate the number of atoms in each of the following:
(a) 52 moles of He (b) 52 amu of He (c) 52 g of He

Q37. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction $4HCl(aq) + MnO_2(s) \rightarrow 2H_2O(l) + MnCl_2(a) + Cl_2(g)$. How many gram of HCl react with 5.0 g of manganese dioxide?

Q38. Find the milli equivalent of:
(a) $Ca(OH)_2$ in 74 g (b) NaOH in 20 g (c) H_2SO_4 in 2.45 g

Q39. On heating 1.763 g of hydrated $BaCl_2$ to dryness, 1.505 g of anhydrous salt remained. What is the formula of hydrate?

Q40. Find out volume of the following at S.T.P.:

(i) 14 g of nitrogen

(ii) 6.023×10^{22} molecules of ammonia (NH_3)

(iii) 0.1 mole of sulphur dioxide (SO_2).

Q41. Calculate number of moles in each of the following:

(i) 11 g of CO_2

(ii) 3.01×10^{22} molecules of CO_2

(iii) 1.12 litre of CO_2 at S.T.P.

Q42. Calculate number of atoms in each of following:

(i) 0.5 mole atoms of nitrogen

(ii) 0.2 mole molecules of nitrogen

(iii) 3.2 g of sulphur.

Q43. Calculate number of atoms of each type in 3.42 g of sucrose ($C_{12}H_{22}O_{11}$).

Date: 14/10/2021

S1. 1 mole of N_2 = 6.023×10^{23} molecules of N_2

= $2 \times 6.023 \times 10^{23}$ atoms of N_2

[$\because$ 1 molecule of N_2 = 2 atoms of N]

Therefore, 0.5 mole of N_2 = $0.5 \times 2 \times 6.023 \times 10^{23}$ atoms of N_2

= 6.023×10^{23} atoms of N_2.

S2. 1 mole of N_2 = 6.023×10^{23} molecule of N_2

Therefore, 0.25 mole of N_2 = $0.25 \times 6.023 \times 10^{23}$ molecule of N_2

= 1.50575×10^{23}

= 1.51×10^{23} molecules of N_2.

S3. Molar mass of H_2O = 18 g mol^{-1}

Now, 9 g water contains $\dfrac{6.023 \times 10^{23} \times 9}{18}$ H_2O molecules

= 3.0115×10^{23} H_2O molecules

S4. Now, molar mass of NH_3 = 17 g/mol

and mass of ammonia = 59.5 g (given)

$\therefore$ $= \dfrac{59.5\text{ g}}{17\text{ g/mol}} = 3.5$ mol.

S5.
$$\text{Molar mass} = \frac{\text{Mass}}{\text{Mole}} = \frac{30\text{ g}}{0.50\text{ mol}} = 60\text{ g mol}^{-1}.$$

S6. Molar mass of CO_2 = 44 g mol^{-1}

Mass = Mole $\times$ Molar mass

= 10 mol $\times$ 44 g mol^{-1} = 440 g.

S7. The molar mass of Ag atoms is equal to the mass of 6.023×10^{23} Ag atoms.

$\therefore$ Mass of an Ag atom = $\dfrac{\text{Molar mass of Ag atoms}}{6.023 \times 10^{23}\text{ atoms/mol}}$

$$= \frac{108\text{ g mol}^{-1}}{6.023 \times 10^{23}\text{ atoms/mol}} = \mathbf{1.79 \times 10^{-22}\text{ g/atom}}.$$

S8. 6.023×10^{23} atoms = 1g atom = 1 mole

$$1 \text{ atom} = \frac{1}{6.023 \times 10^{23}}$$

$$= \mathbf{1.66 \times 10^{-24}\, g} \text{ atom or mol.}$$

S9. The ratio of the mass of a silver atom to the mass of a carbon atom is the same as the ratio of the mass of 6.023×10^{23} Ag atoms to the mass of 6.023×10^{23} C atoms. But the mass of 6.023×10^{23} atoms is equal to the molar mass of the atoms.

$$\therefore \quad \frac{\text{Mass of silver atom}}{\text{Mass of a carbon atom}} = \frac{\text{Mass of } 6.023 \times 10^{23} \text{ Ag atoms}}{\text{Mass of } 6.023 \times 10^{23} \text{ C atoms}}$$

$$= \frac{\text{Molar mass of Ag atoms}}{\text{Molar mass of C atoms}}.$$

The molar mass of C atoms is 12 g mol^{-1} and let the molar mass of Ag atoms be M(Ag).

Therefore,

$$\frac{9}{1} = \frac{M(\text{Ag})}{12\,\text{g/mol}^{-1}}$$

and $\quad M(\text{Ag}) = 9 \times 12 \text{ g mol}^{-1} = 108 \text{ g mol}^{-1}.$

S10. A 100 g sample of chlorophyll contains 2.68 g magnesium

$\therefore$ A 2 g sample of chlorophyll contains $2 \times 2.68/100 = 0.0536$ g Mg

$$\text{Mole of Mg} = \frac{\text{Mass of Mg}}{\text{Molar mass of Mg}} = \frac{0.0536 \text{ g}}{24 \text{ g/mol}} = 2.23 \times 10^{-3} \text{ mol}$$

$$\text{Number of Mg atoms} = \text{Mole of Mg atoms} \times 6.023 \times 10^{23} \text{ mol}^{-1}$$

$$= 2.23 \times 10^{-3} \text{ mol} \times 6.023 \times 10^{23} \text{ mol}^{-1}$$

$$= 1.34 \times 10^{21} \text{ atoms.}$$

S11. 3.116×10^{9} molecules of $X = 10^{-12}$ g

$$1 \text{ molecules of } X = \frac{10^{-12}}{3.0115 \times 10^{9}} = 3.32 \times 10^{-22} \text{ g}$$

$$= 20\,\text{g} = \mathbf{200\ amu}.$$

S12.

$$\underset{\substack{276\text{ g} \\ (108 \times 2 + 12 + 16 \times 3)}}{Ag_2CO_3} \xrightarrow{\Delta} \underset{\substack{216\text{ g} \\ (108 \times 2)}}{2Ag} + CO_2 + 1/2O_2$$

$$276\,\text{g of } Ag_2CO_3 \Rightarrow 216\,\text{g of Ag}$$

$$2.76\,\text{g of } Ag_2CO_3 \Rightarrow 2.16\,\text{g of Ag}$$

S13. 1 micro gram = 1 mg = 10^{-6} g

1 mole of C = 12 g = 6.023×10^{23} atoms

12 g of C = 6.023×10^{23} atoms

$$10^{-6} \text{ g of C} = \frac{6.023 \times 10^{23} \times 10^{-6}}{12} = \mathbf{5 \times 10^{16} \text{ atoms of C}}.$$

S14. 1 mole of $CaCl_2$ = 40 + 35.5 × 2 = 111 g

$$\underset{1\text{ mol}}{CaCl_2} \longrightarrow \underset{1\text{ mol}}{Ca^{2+}} + \underset{2\text{ mol}}{2Cl^{\ominus}}$$

In 222 g, Ca^{2+} has 2 mols and Cl^- as 4 mols.

1 mole Cl^- = 6.023×10^{23} ions

4 mole Cl^- = $4 \times 6.023 \times 10^{23}$ ions

= 24.092×10^{23} ions

1 mole of Ca^{2+} = 6.023×10^{23} ions

2 mole of Ca^{2+} = 12.046×10^{23} ions.

S15. 44 g of CO_2 = 1 mol = 6.023×10^{23} molecules

$\therefore$ 6.023×10^{23} molecules = 44 g of CO_2

$$10^{21} \text{ molecules} = \frac{44 \times 10^{21} \times 10^{3}}{6.023 \times 10^{23}} \text{ mg} = 73.05 \text{ mg}$$

$$\text{Weight of } CO_2 \text{ left} = 200 - 73.05 = 126.9 \text{ mg } \frac{126.9}{10^3} = 0.1269 \text{ g}$$

44 g of CO_2 = 1 mol

$$0.1269 \text{ g of } CO_2 = \frac{1}{44} \times 0.1269 = \mathbf{0.0028 \text{ mol}}.$$

S16. 10 lakh = 10 × 100000 = 10^6

1 Avogadro's number of rupees = 6.023×10^{23}

10^6 rupees $\Rightarrow$ 1 s

$$6.023 \times 10^{23} \text{ rupees} = \frac{1 \times 6.023 \times 10^{23}}{10^6} \text{ s}$$

$$= \frac{6.023 \times 10^{23}}{10^6 \times 60 \times 60 \times 24 \times 365} \text{ years}$$

$$= \mathbf{1.9099 \times 10^{10} \text{ years}}.$$

S17. (a) One molecule of ethane contains two carbon atoms. Hence 3 moles of ethane molecules will contain 3 × 2 = **6** moles of carbon atoms.

(b) One molecule of ethane contains six hydrogen atoms. Hence 3 moles of ethane molecules will contain $3 \times 6 =$ **18** moles of hydrogen atoms.

(c) One mole of ethane contains 6.022×10^{23} ethane molecules. Hence 3 moles of tehane will contain $3 \times 6.022 \times 10^{23} = \mathbf{1.8066 \times 10^{24}}$ ethane molecules.

S18. (a) Number of moles of Na = $\frac{1}{23}$

$\therefore$ Number of atoms of Na = $\frac{1}{23} \times 6.022 \times 10^{23} = 2.62 \times 10^{22}$

(b) Atomic weight of Li is 6.9

$\therefore$ Number of moles of Li = $\frac{1}{6.9}$

$\therefore$ Number of atoms of Li = $\frac{1}{6.9} \times 6.022 \times 10^{23} = 8.73 \times 10^{22}$.

Li(s) has largest number of atoms.

S19. Mass of all the atoms in haemoglobin

$$
\begin{aligned}
3032 \times C &= 3032 \times 12 = 36384 \\
4740 \times H &= 4740 \times 1 = 4740 \\
896 \times O &= 896 \times 16 = 14336 \\
760 \times N &= 760 \times 14 = 10640 \\
12 \times S &= 12 \times 32 = 384 \\
4 \times Fe &= 4 \times 56 = 224 \\
\text{Molecular mass} &= 66708
\end{aligned}
$$

Mass percentage of Fe in haemoglobin

$$= \frac{\text{Mass of iron atoms}}{\text{Molecular mass of haemoglobin}} \times 100$$

$$= \frac{224}{66708} \times 100 = 0.336\% .$$

S20. Molucular mass of Na_2SO_4 = 2 Na + S + 4O = 2×23 u + 32 u + 4×16 u = 142 u

Mass per cent of Na = $\frac{2 \times 23 \text{ u}}{142 \text{ u}} \times 100 = 32.39\%$

Mass per cent S = $\frac{32 \text{ u}}{142 \text{ u}} \times 100 = 22.54\%$

Mass per cent of Na = $\frac{4 \times 16 \text{ u}}{142 \text{ u}} \times 100 = 45.07\%$

S21. $M(C_7H_5N_3O_6) = 7C + 5H + 3N + 6O$

$$= 7 \times 12 + 5 \times 1 + 3 \times 14 + 6 \times 16 = 227 \text{ g mol}^{-1}$$

$\because$ 227 g TNT contains 42 g N atoms

$\therefore$ 192 g TNT contains $\frac{42 \times 192}{227}$ N atoms = 35.524 g N atoms

Number of moles of N atoms = $\frac{\text{Mass of N atoms}}{\text{Molar mass of N atoms}} = \frac{35.524 \text{ g}}{14 \text{ g/mol}^{-1}}$ = 2.537 mol.

S22. Number of atoms = $\frac{\text{Mass of substance}}{\text{Molar mass of substance}} \times$ Avogadro constant

From this relation it is clear that number of atoms is directly proportional to the mass and inversely proportional to the molar mass. Thus,

(a) Number of atoms in 1 g of Au = $\frac{1 \text{g}}{197 \text{ g/mol}} \times 6.022 \times 10^{23}$.

$$= 0.005 \times 6.0 \times 10^{23}$$

$$= 0.030 \times 10^{23} = 3.0 \times 10^{21}$$

(b) Number of atoms in 1 g of $Cl_2(g)$ = $\frac{1 \text{ g}}{71 \text{ g/mol}} \times 6.022 \times 10^{23}$.

$$= 0.014 \times 6.0 \times 10^{23}$$

$$= 0.084 \times 10^{23} = 8.4 \times 10^{21}$$

Conclusion: 1 g of Cl_2 will have largest number of atoms.

Reason: The molar mass of Cl_2 is the lower than Au.

S23. Mass of magnesium in 5.00 g of complex = $\frac{2.68}{100} \times 5.00 = 0.134 \text{ g}$

Gram atomic mass of magnesium = 24 g

24 g of magnesium contain = 6.02×10^{23} atoms

0.134 g of magnesium would contain = $\frac{6.02 \times 10^{23}}{24} \times 0.134 = 3.36 \times 10^{21}$ atoms

Therefore, 5.00 g of the given complex would contain 3.36×10^{21} atoms of Mg.

S24. 40 g of calcium contain = 6.023×10^{23} atoms

$\therefore$ 4 g of calcium contain = $\frac{6.023 \times 10^{23}}{40} \times 4 = 6.023 \times 10^{22}$ atoms

Now, 6.023×10^{23} atoms of sodium have mass = 23 g

$\therefore$ 6.023×10^{22} atoms of sodium have mass = $\frac{23}{6.023 \times 10^{23}} \times 6.023 \times 10^{22} = 2.3$ g.

S25. Gram molecular mass of $H_2C_2O_4 . 2H_2O$ = 126 g

Now, water molecules in 1 mol of oxalic acid = 2 mol.

or water molecules in 126 g of oxalic acid = $2 \times 6.023 \times 10^{23}$

$\therefore$ Water molecules in 252×10^{-3} g of oxalic acid = $\dfrac{2 \times 6.023 \times 10^{23} \times 252 \times 10^{-3}}{126} = 2.4 \times 10^{21}$.

S26. Gram formula mass of $CaCO_3$ = 100 g

Now, 1 mole of $CaCO_3$ contain = 3 mole of O atoms.

or 100 g of $CaCO_3$ contain = $3 \times 6.02 \times 10^{23}$ O atoms

$\therefore$ 300 g of $CaCO_3$ contain O atoms = $\dfrac{3 \times 6.023 \times 10^{23}}{100} \times 300 = 54.207 \times 10^{23}$

and, $= 5.4207 \times 10^{24}$ Oxygen atoms.

S27. (i) Gram molecular mass of nitrogen = 28 g

28 g of nitrogen contain = 6.023×10^{23} molecules

$\therefore$ 14 g of nitrogen contain = $\dfrac{6.023 \times 10^{23}}{28} \times 14 = 3.01 \times 10^{23}$ molecules.

(ii) Gram molecular mass of H_2S = (2 + 32) g = 34 g

34 g of H_2S contain = 6.023×10^{23} molecules

3.4 g of H_2S contain = $\dfrac{6.023 \times 10^{23}}{34} \times 3.4 = 6.023 \times 10^{22}$ molecules.

S28. (i) Mass of 6.023×10^{23} atoms of calcium = gram atomic mass of calcium = 40 g

$\therefore$ Mass of 1 atom of calcium = $\dfrac{40}{6.023 \times 10^{23}} = \mathbf{6.6 \times 10^{-23}}$ **g** (Approx.).

(ii) Mass of 6.023×10^{23} molecules of SO_2 = gram molecular mass of SO_2 = 64 g

$\therefore$ Mass of 1 molecular of SO_2 = $\dfrac{64\,g}{6.023 \times 10^{23}} = \mathbf{1.06 \times 10^{-22}}$ **g** (Approx.).

S29. 1 mole of H_2O = 18 g = 18 cm³ $(\because\ d_{H_2O} = 1\ g\ cm^{-3})$

$= 6.022 \times 10^{23}$ molecules of H_2O

Therefore, volume of 1 molecule of H_2O

$= \dfrac{18}{6.022 \times 10^{23}}\ cm^3 = \mathbf{2.989 \times 10^{-23}\ cm^3}$.

S30. Volume of 1 drop of H_2O = 0.04 mL

Weight of 1 drop of H_2O = Volume $\times$ Density

$= 0.04 \times 1 = 0.04\,g$

1 mole of H_2O = 1.8 g = 6.023×10^{23} molecules

$\therefore$ $0.04\,g = \dfrac{6.023 \times 10^{23} \times 0.04}{18}$ = **1.3384×10^{21} molecules**.

S31. Molar mass of benzene (C_6H_6) = $12 \times 6 + 1 \times 6 = 78\,g$

1 litre of benzene = 1000 mL

Mass of 1000 mL of benzene = Volume $\times$ Density

$= 1000 \times 0.88 = 880\,g$

$\therefore$ 78 g of benzene = 6.023×10^{23} molecules

880 g of benzene = $\dfrac{6.023 \times 10^{23} \times 880}{78}$

= **6.795×10^{24} molecules**.

S32. $\because$ 4 g helium has 6.023×10^{23} atoms

$\therefore$ 1 g helium has $\dfrac{6.023 \times 10^{23}}{4}$ atoms = 1.506×10^{23} atoms

Also,

$\because$ 4 g helium has volume at S.T.P. = 22.4 L

$\therefore$ 1 g helium haas volume at S.T.P. = $\dfrac{22.4}{4}$ = **5.6 L**.

S33. $\because$ N atoms have 1 g atom = 6.023×10^{23} atoms

$\therefore$ 2×10^{23} atom = $\dfrac{2 \times 10^{23}}{6.023 \times 10^{23}}$ = 0.33 g atom

$\because$ N atoms of element weight 32 g

$\therefore$ 2×10^{23} atoms of element weight = $\dfrac{32 \times 2 \times 10^{23}}{6.023 \times 10^{23}}$ = **10.63 g**.

S34. $\because$ 100 g haemoglobin has = 0.25 g Fe

$\therefore$ 89600 g haemoglobin has = $\dfrac{0.25 \times 89600}{100}$ = 224 g Fe

$\therefore$ 1 mol or N molecules of haemoglobin has

$= \dfrac{224}{56}$ g atom Fe

= **4 g atom Fe**.

Therefore, 1 molecule of haemolobin has 4 atom of Fe.

S35. (a) The formula $(NH_4)_2SO_4 . FeSO_4 . 6H_2O$ contains 2N, 20H, 2S, 1Fe and 14O atoms

(b) Mass of all atoms:

$$\begin{aligned} 2 \times N &= 2 \times 14 = 28\text{ g} \\ 20 \times H &= 20 \times 1 = 20\text{ g} \\ 2 \times S &= 2 \times 32 = 64\text{ g} \\ 1 \times Fe &= 1 \times 56 = 56\text{ g} \\ 14 \times O &= 14 \times 16 = \underline{224\text{ g}} \\ \text{Molar mass} &= 392\text{ g} \end{aligned}$$

$$\text{Percentage of an atom} = \frac{\text{Mass of that atom}}{\text{Molar mass}} \times 100$$

$$\text{Percentage of N in Mohr salt} = \frac{28\text{ g}}{392\text{ g}} \times 100 = 7.14\%$$

$$\text{Percentage of H in Mohr salt} = \frac{20\text{ g}}{392\text{ g}} \times 100 = 5.10\%$$

$$\text{Percentage of S in Mohr salt} = \frac{64\text{ g}}{392\text{ g}} \times 100 = 16.33\%$$

$$\text{Percentage of Fe in Mohr salt} = \frac{56\text{ g}}{392\text{ g}} \times 100 = 14.28\%$$

$$\text{Percentage of O in Mohr salt} = \frac{224\text{ g}}{392\text{ g}} \times 100 = 57.14\%$$

(c) $$\text{Percentage of water in Mohr salt} = \frac{\text{Mass of water}}{\text{Molar mass of salt}} \times 100$$

$$= \frac{6 \times 18\text{ g}}{392\text{ g}} \times 100 = 27.55\%.$$

S36. (a) Number of He atoms in 52 moles $= 52 \text{ moles} \times 6.023 \times 10^{23}$ atoms

$= 3.13 \times 10^{25}$ atoms

(b) Atomic mass of He = 4 amu = mass of one He atom

$\therefore$ Number of atoms in 52 amu of He $= \dfrac{52\text{ amu}}{4\text{ amu/atom}} = 13$ atoms

(c) Number of atoms in 4 g of He $= \dfrac{4\text{ g}}{4\text{ g}} \times 6.023 \times 10^{23} = 6.023 \times 10^{23}$

$\therefore$ Number of atoms in 52 g He $= \dfrac{52\text{ g}}{4\text{ g}} \times 6.023 \times 10^{23}\text{ mol}^{-1} = 7.83 \times 10^{24}$.

S37.

$$\begin{array}{ccccccccc} x & & 5.0\text{ g} & & & & & & \\ 4HCl(aq) & + & MnO_2(s) & \longrightarrow & 2H_2O(l) & + & MnCl_2(aq) & + & Cl_2(g) \\ 4\text{ mol} & & 1\text{ mol} & & & & & & \\ 4\times 36.5\text{ g} & & (54.94+2\times 16)\text{ g} & & & & & & \\ 146\text{ g} & & 86.94\text{ g} & & & & & & \end{array}$$

Ratio proportion: $\dfrac{x}{146\text{ g}HCl} = \dfrac{5.0\text{ g}MnO_2}{86.94\text{ g}MnO_2}$

$\therefore$ $x = \dfrac{5.0\text{ g}MnO_2}{86.94\text{ g}MnO_2} \times 146\text{ g}HCl$

$= 8.396\text{ g}HCl = 8.4\text{ g}HCl.$

S38. (a) mEq of $Ca(OH)_2 = \dfrac{W}{E} \times 1000 = \dfrac{74}{74/2} \times 1000 = 2000$

(b) mEq of $NaOH = \dfrac{20}{40} \times 1000 = 500$ $(\because\ E_{NaOH} = 40)$

(c) mEq of $H_2SO_4 = \dfrac{2.45}{49} \times 1000 = 50$ $(\because\ E_{H_2SO_4} = 49)$

S39. Let the formula of hydrate = $BaCl_2 \cdot nH_2O$

$BaCl_2 \cdot nH_2O = (137 + 2\ \ 35.5 + 18n) = (208 + 18n)\text{ g}$

Molar mass $BaCl_2 = 137 + 71 = 208\text{ g}$

Moles of anhydrous $BaCl_2 = \dfrac{1.505}{208} = 0.00724$

Mass of water = $1.763 - 1.505 = 0.258$

Moles of water = $0.258/18 = 0.01433$

Moles of water in hydred = $\dfrac{0.01433}{0.00724} = 2$

Formula $\Rightarrow BaCl_2 \cdot 2H_2O$.

S40. (i) Molecular mass of $N_2 = 28$

28 g of N_2 occupy at S.T.P. = 22.4 litres

$\therefore$ 14 g of N_2 occupy at S.T.P. = $\dfrac{22.4}{28} \times 14 = 11.2$ litre

(ii) 6.023×10^{23} molecules of NH_3 occupy at S.T.P. = 22.4 litres

$\therefore$ 6.023×10^{22} molecules of MH_3 occupy at S.T.P. = $\dfrac{22.4}{6.023 \times 10^{23}} \times 6.023 \times 10^{22} = 2.24$ L

(iii) 1 mole of SO_2 occupies at S.T.P. = 22.4 litres

$\therefore$ 0.1 mol of SO_2 occupies at S.T.P. = $\frac{22.4}{1} \times 0.1 = 2.24$ L

S41. (i) Molecular mass of CO_2 = 44

44 g of CO_2 = 1 mole of CO_2

11 g of CO_2 = $\frac{1}{44} \times 11 = 0.25$ mol.

(ii) 6.02×10^{23} molecules of CO_2 = 1 mole of CO_2

3.01×10^{22} molecules of CO_2 = $\frac{1}{6.02 \times 10^{23}} \times 3.01 \times 10^{22} = 0.05$ mol.

(iii) 22.4 litres of CO_2 at S.T.P. = 1 mole of CO_2

1.12 litres of CO_2 at S.T.P. = $\frac{1}{22.4} \times 1.12 = 0.05$ mol.

S42. (i) 1 mole atoms of nitrogen = 6.023×10^{23} atoms

$\therefore$ 0.5 mole atoms of nitrogen = $6.023 \times 10^{23} \times 0.5 = 3.01 \times 10^{23}$ atoms.

(ii) 1 mole molecules of nitrogen = 6.023×10^{23} atoms

$\therefore$ 0.2 mole atoms of nitrogen = $6.023 \times 10^{23} \times 0.2$

$= 1.2046 \times 10^{23}$ molecules

1 molecule of nitrogen = 2 atoms

1.2046×10^{23} molecules of nitrogen = $1.2046 \times 10^{23} \times 2$ = $\mathbf{2.409 \times 10^{23}}$ **atoms**.

(iii) 32 g sulphur contain = 6.023×10^{23} atoms

$\therefore$ 3.2 g of sulphur contain = $\frac{6.023 \times 10^{23} \times 3.2}{32} = 6.023 \times 10^{22}$ atoms.

S43. Molecular mass of sucrose = $(12 \times 12 + 1 \times 22 + 16 \times 11) = 342$

342 g of sucrose contain = 6.03×10^{23} molecules

$\therefore$ 3.42 g of sucrose contain = $\frac{6.03 \times 10^{23}}{342} \times 3.42$

$= 6.023 \times 10^{21}$ molecules

Number of atoms of carbon in 3.42 g of sucrose

1 molecule of sucrose contains = 12 atoms of carbon

6.023×10^{21} molecules of sucrose contain $= 12 \times 6.023 \times 10^{21}$ atoms of carbon

$= 72.28 \times 10^{21}$ atoms of carbon

Number of atoms of hydrogen in 3.42 g of sucrose

1 molecule sucrose contains = 22 atoms of hydrogen

6.023×10^{21} molecules of sucrose contain $= 22 \times 6.023 \times 10^{21}$ atoms of hydrogen

$= 132.5 \times 10^{21}$ atoms of hydrogen

Number of atoms of oxygen in 3.42 g of sucrose

1 molecule of sucrose contains = 11 atoms of oxygen

6.023×10^{21} molecules of sucrose contain $= 11 \times 6.023 \times 10^{21}$ atoms of oxygen

$= 66.25 \times 10^{21}$ atoms of oxygen

Date: 14/10/2021

Q1. What is the molarity of a solution prepared by mixing 2.0 L of 3 M glucose solutions and 3.0 L of 2.5 M glucose solution?

Q2. Define mole fraction of a component in a solution.

Q3. What is the sum of the mole fractions of all the components in a three component system?

Q4. Will the molarity of a solution at 50°C be same, less or more than molarity at 25°C?

Q5. Which out of molarity or molality will change with change in temperature and why?

Q6. Ethanol is an organic compound, yet it is freely miscible with water. Explain.

Q7. How is the molality of a solution different from its molarity?

Q8. Calculate the mass percentage of aspirin (C_9H_8O) in acetonitrile (CH_3CN) when 6.5 g of $C_9H_8O_4$ is dissolved in 450 g of CH_3CN.

Q9. A solution contains 20 g NaCl in 95 cm^3 solution. The density of the solution is 1.25 gcm^{-3}. What is mass% of NaCl?

Q10. A solution contains 3.2 g methanol per 500 cm^3 of the solution. Calculate its molarity.

Q11. Calculate the volume of water which should be added to 20 ml of 0.65 M HCl to dilute the solution to 0.2 M.

Q12. Caluclate the molarity of solution containing 10 g NaOH is dissolved in 900 ml. solution.

Q13. Calculate the mass of sodium acetate (CH_3COONa) required to make 500 mL of 0.375 molar aqueous solution. Molar mass of sodium acetate is 82.0245 g mol^{-1}.

Q14. Molality of an aqueous solution is 1.002 mol/kg. What is mol fraction of solute.

Q15. The density of water of lake is 1.25 g/ml and one kg of this water contains 98 g of Na^+ ions. What is the molarity of Na^+ ions in the water of lake. Atomic mass of Na = 23.00 u)

Q16. Concentrated nitric acid used in the laboratory work is 68% nitric acid by mass in aqueous solution. What should be molarity of such sample of the acid if the density of solution is 1.504 g mL^{-1}?

Q17. Calculate weight of Baking soda ($NaHCO_3$) required in making 400 gram of 0.50 molal aqueous solution.

Q18. Calculate the mole fraction of benzene in a solution, containing 40% by mass in CCl_4.

Q19. Calculate molality of 2.5 g of ethanoic acid (CH_3COOH) in 500 g benzene.

Q20. The density of 3 M solution of NaCl is 1.25 g mL^{-1}. Calculate molality of the solution.

Q21. Molarity of sulphuric acid solution is 15.68. What volume of this solution would be needed to prepare 1 litre of 0.2 M H_2SO_4 solution?

Q22. Answer of the following question is a single digit integer ranging from 0 to 9:
A compound H_2X with molar weight of 80 g is dissolved in a solvent having density of 0.4 g ml^{-1}. Assuming no change in volume upon dissolution, find the molarity of a 3.2 molar solution.

Q23. If the density of methanol is 0.793 kg L^{-1}, What is its volume needed for making 2.5 L of its 0.25 M solution?

Q24. Calculate the number of Cl^- ions in 100 ml of 0.001 M HCl solution.

Q25. Calculate the molarity of pure water (Density of water = 1 g mL^{-1})

Q26. Calculate the amount of benzoic acid (C_6H_5COOH) required for preparing 250 mL of 0.15 M solution in methanol.

Q27. Calculate the mass percentage of benzene (C_6H_6) and carbon tetrachloride (CCl_4) if 22 g of C_6H_6 is dissolved in 122 g of CCl_4.

Q28. How would you prepare 0.25 m $CaCl_2$ solution?

Q29. A solution is prepared by dissolving 0.409 g sulphuric acid in 100 cm^3 of the solution. Calculate its normality.

Q30. Calculate the number of oxalic acid molecules in 100 mL of 0.02 N oxalic acid solution.

Q31. Calculate the normality of NaOH when 2 g is present in 800 mL solution.

Q32. Calculate the normality of the resulting solution made by adding 2 drops (0.10 mL) of 0.1 N H_2SO_4 in 1 litre of distilled water.

Q33. Calculate the normality of mixture obtained by mixing
(a) 100 mL of 0.1 N HCl + 50 mL of 0.25 N NaOH
(b) 100 mL of 0.2 N H_2SO_4 + 200 mL of 0.2 M HCl

Q34. What volume of water is required to make 0.20 N solution from 1600 mL of 0.2050 N solution?

Q35. Calculate molality of 1 litre solution of 93% H_2SO_4 weight by volume. The density of solution is 1.84 g mL^{-1}.

Q36. Mole fraction of I_2 in C_6H_6 is 0.2. Calculate molality of I_2 in C_6H_6. (*Mw* of C_6H_6 = 78 g mol^{-1})

Q37. Calculate the molality of a sulphuric acid solution in which the mole fraction of water is 0.85.

Q38. A 6.90 M solution of KOH contains 30% by weight of KOH. Calculate the density of the solution.

Q39. 3.5 litre of 0.01 M NaCl is mixed with 1.5 litre of 0.05 M NaCl. What is the concentration of the final solution?

Q40. How is the molality of a solution different from its molarity? What is the effect of change in temperature of a solution on its molality and molarity?

Q41. Calculate the molarity of the following:
(a) 30 g of $Ca(NO_3)_2 \cdot 3H_2O$ in 4.3 L
(b) 50 ml of 0.5 m $\cdot$ H_3PO_4 diluted to 500 ml

Q42. A solution of glucose in water is labelled as 10 per cent w/w, what would be the molality and mole fraction of each commponent in the solution? If the density of the solution is 1.2 g ML^{-1}, then what shall be the molarity of the solution?

Q43. A solution is obtained by mixing 300 g of 25% and 400 g of 40% solution by mass. Calculate the mass percentage of resulting solution.

Q44. An antifreeze solution is prepared from 222.6 gram of ethylene glycol $C_2H_6O_2$ and 200 g of water. Calculate molality and molarity of solution if density of solution is 1.072 g/mL.

Q45. Calculate the molality of K_2CO_3 solution which is formed by dissolving 2.5 g of it in one litre of solution density of solution is 0.85 g/ml.

Q46. A sugar syrup of weight 214.2 g contains 34.2 g of sugar ($C_{12}H_{22}OH$). Calculate (i) mole fraction of sugar (ii) molality of sugar syrup.

Q47. A solution of oxalic acid, $(COOH)_2 \cdot 2H_2O$ is prepared by dissolving 0.63 g of the acid in 250 mL of the solution. Calculate (a) molarity and (b) normality of the solution.

Q48. How many moles and how many grams of sodium chloride are present in 250 mL of a 0.50 M NaCl solution?

Q49. 2.82 g of glucose (molar mass = 180) are dissolved in 30 g of water. Calculate (a) the molality (b) mole fraction of glucose and water.

Q50. The density of 3 M sodium thiosulphate solution ($Na_2S_2O_3$) is 1.25 g per ml. Calculate
(a) the percentage by weight of sodium thiosulphate,
(b) the mole fraction of sodium thiosulphate and
(c) the molarities of Na^+ and $S_2O_3^{2-}$ ions.

Q51. Answer of the following question is a single digit integer ranging from 0 to 9:
29.2% (w/w) HCl stock solution has a density of 1.25 g mL^{-1}. The molecular weight of HCl is 36.5 g mol^{-1}. What is the volume (mL) of stock solution required to prepare a 200 mL solution of 0.4 M HCl.

Q52. Calculate normality and molarity of the following:
(a) 0.74 g of $Ca(OH)_2$ in 5 mL of solution (b) 1.10 mol of H_2SO_4 in 500 mL of solution.

Q53. A bottle of commercial sulphuric acid (d = 1.787 g mL^{-1}) is 86% by weight.
(a) What is the molarity of the acid?
(b) What is volume of the acid has to be used to make 1 L of 0.2 M H_2SO_4?
(c) What is the molaliy of the acid?

Date: 14/10/2021

S1. For mising of two solutions,

$$M_1 V_1 + M_2 V_2 = M_3 (V_1 + V_2)$$

Putting the appropriate values, $M_3 = \dfrac{3 \times 2 + 2.5 \times 3}{2 + 3} = \dfrac{6 + 7.5}{5} = \dfrac{13.5}{5}$ = **2.7 M**.

S2. Mole fraction of a component in a solution is the ratio of the moles of the components to the sum of the components of different fraction.

$$\chi_A = \frac{n_A}{n_A + n_B}$$

where χ_A is the mole fraction and n_A and n_B are the number of moles of components *A* and *B*.

S3. The sum of the mole fractions of all the components in a three component system is one

$$\frac{n_A}{n_A + n_B + n_C} + \frac{n_B}{n_A + n_B + n_C} + \frac{n_C}{n_A + n_B + n_C} = 1$$

where n_A, n_B, n_C are the moles of the three components.

S4. Molarity at 50°C of a solution will be less than that at 25°C because molarity decreases with temperature. This is because volume of the solution increases with increase in temperature but number of moles of solute remains the same.

S5. Molarity changes with rise in temperature, because volume of a solution increases with rise in temperature. This causes change in molarity as it is related to moles of solute in a given volume of solution.

S6. Because C_2H_5OH is polar ($O^{\delta-}$ — $H^{\delta+}$) and hydrophobic part C_2H_5— is very small in size, hence C_2H_5OH can break hydrogen bonding of water, and can make H-bonding with H_2O.

S7. Molarity is the number of moles of solute per litre of the solution while molality is the number of moles of solute per kilogram of the solvent. Molarity depend on temperature while molality independent from temperature.

S8. **Given:** Mass of aspirine (Solute) = 6.5 g

Mass of CH_3CN (Solvent) = 450 g

Mass of solution = 450 + 6.5 = 456.5 g

$$\text{Mass percentage of solute} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100 = \frac{6.5}{450 + 6.5} \times 100 = \mathbf{1.424\%}.$$

S9. Given, Density of solution = 1.25 gcm^{-3}

Volume of solution = 95 cm^3

Mass of solution = 95 $cm^3 \times 1.25\ gcm^{-3}$ = 118.75 g

$$\text{Mass \% NaCl} = \frac{\text{Mass of solute}}{\text{Mass of the solution}} \times 100 = \frac{20}{118.75} \times 100 = \mathbf{1.69\%}.$$

S10. Molar mass of methanol (CH_4O) = 32 g.mol

$$\text{Number of moles of methanol} = \frac{\text{Mass of methanol}}{\text{Molar mass of methanol}} = \frac{3.2}{32} = 0.1 \text{ mol}$$

$$\text{Molarity of methanol in } 500\,cm^3 \text{ solution} = \frac{\text{No. of moles of methanol}}{\text{Volume of solution (in L)}} = \frac{0.1}{500/1000} = \mathbf{0.2\ M}.$$

S11. For dilution, $M_1 V_1 = M_2 V_2$

$$V_2 = \frac{M_1V_1}{M_2} = \frac{0.65 \times 20}{0.2} = 65 \text{ ml.}$$

Vol. of water to be added to 20 ml of 0.65 M solution $= V_2 - V_1 = 65 - 20 =$ **45 ml**.

S12. Given:

Solute (W_B) = 10 g (NaOH)

Solution (V) = 900 ml

Molar weight (M_B) = 40 g mol^{-1}

$$M = \frac{n_B \times 1000}{V(ML)} = \frac{W_B \times 1000}{M_B \times V(ML)}$$

$$= \frac{10 \times 1000}{40 \times 900} = \mathbf{0.278}.$$

S13.

$$\text{Molarity} = \frac{\text{Number of moles}}{\text{Volume in litres}}$$

$\because$ $$\text{Number of moles} = \frac{\text{Mass in grams}}{\text{Molecular weight}} = \frac{\text{Mass in grams}}{82.0245}$$

and $$\text{Volume in litres} = \frac{\text{Volume in mL}}{1000} = \frac{500}{1000}$$

$\therefore$ $$0.375 = \frac{\text{Mass in grams} \times 1000}{82.0245 \times 500}$$

$\therefore$ $$\text{Mass in grams} = \frac{0.375 \times 82.0245 \times 500}{1000} = \mathbf{15.38\ g}.$$

S14. Given:

$$M = 1.002 \text{ mol/kg}$$

And $$X_B = \frac{n_B}{n_A + n_B}.$$

If molality is 1.002 mol/kg, we can take number of moles of solute (W_B) = 1.002 mol.

Weight of solvent = 1000 gram

And, solvent is H_2O, molar mass (M_B) = 18.

Hence, number of moles of solbent = $\frac{1000}{18}$ = **55.5**

i.e., $$X_B = \frac{1.002}{55.5 + 1.002} = \frac{1.002}{56.502} = \mathbf{0.017}.$$

S15. Given:

Weight of solvent (W_A) = 1 kg H_2O = 1000 g H_2O

Density of solution = 1.25 g/ml

Weight of solute (W_B) = 98 g (Na^+)

Atomic weight (M_B) = 23.00 u

Molarity = M

$$M = \frac{n_B \times 1000}{V} \qquad \left(d = \frac{W}{V}\right)$$

Or $$= \frac{n_B \times d \times 1000}{W} = \frac{98 \times 1.25 \times 1000}{23 \times 1000} = \mathbf{5.32\ mol/Lit}.$$

S16. Given:

68% HNO_3 by mass means 68 g HNO_3 dissolve in 100 g solution

We know that

$\therefore$ $$\text{Volume of solution} = \frac{\text{Mass of solution (W)}}{\text{Density (d)}} \left(\text{Density} = \frac{\text{Mass}}{\text{Volume}}\right)$$

$$= \frac{100}{1.504} = 66.49 \text{ ml}$$

We know that

Mass of solute (W_B) = 68 g

Molar mass of solute HNO_3 = 63 g mol^{-1}

Volume of solution = 66.49 ml

$$\text{Molarity (M)} = \frac{W_B \times d \times 1000}{M_B \times W} \qquad \left(\because \quad \frac{W}{d} = \text{Volume}\right)$$

$$= \frac{68 \times 1.504 \times 1000}{63 \times 100} = \mathbf{16.23\ M}$$

S17. Given:

$$\text{Molality} = 0.50\ M'$$

$$\text{Molar weight of solute } (M_B) = (NaHCO_3) = 84 \text{ g/mol}$$

$$\text{Weight of solvent } (W_A) = 400 \text{ gram}$$

$$M' = \frac{n_B \times 1000}{W_A}$$

or

$$M' = \frac{W_B \times 1000}{M_B \times W_A}$$

$$0.50 = \frac{W_B \times 1000}{84 \times 400}$$

$$W_B = \frac{84 \times 0.50 \times 400}{1000} = \mathbf{16.8\ gram}$$

S18. Let,

Weight of solution = 100 gram

Weight of benzene = 40 gram

Weight of CCl_4 = 60 gram

Molar mass of benzene = 78 g/mol

Molar mass of CCl_4 = 154 g/mol

$$X_B = \frac{n_{C_6H_6}}{n_{C_6H_6} + n_{CCl_4}}$$

$$= \frac{40/78}{40/78 + 60/154} = \frac{0.5128}{0.5128 + 0.3896}$$

$$= \frac{0.5128}{0.9024} = 0.568 = \mathbf{0.57}.$$

S19. Given:

Weight of solute (W_B) = 2.5 g (ethanoic acid)

Weight of solvent (V) = 500 gram (benzene)

Molar mass of solute (M_B) = 60 g/mol^{-1} (ethanoic acid)

$$\text{(Molality) } M' = \frac{n_B \times 1000}{W_A \text{ (gram)}} = \frac{W_B \times 1000}{M_B \times W_A}$$

$$= \frac{2.5 \times 1000}{60 \times 500} = \mathbf{0.083}.$$

S20. Let us consider 1 litre of NaCl solution.

Number of moles of NaCl = 3

Mass of NaCl = Number of moles Molecular weight

$= 3 \times (23 + 35.5) = 175.5\,\text{g}$

Mass of solution = Density $\times$ Volume = $1.25\,\text{mL}^{-1} \times 1000\,\text{mL} = 1250\,\text{g}$

Mass of solvent = $1250 - 175.5 = 1074.5\,\text{g}$

$$\therefore \quad \text{Molality} = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in grams}} \times 1000$$

$$= \frac{3}{1074.5} \times 1000 = \mathbf{2.79\ m}.$$

S21. Number of milli-moles of H_2SO_4 in the dilute solution = $M \times V = 0.2 \times 1000 = 200$.

Number of milli-moles of H_2SO_4 in the stock solution $M \times V = 15.68 \times V$

Since the number of milli-moles of H_2SO_4 remains unchanged on dilution, therefore

$15.68 \times V = 200$

$$\therefore \quad V = \frac{200}{15.68} = \mathbf{12.76\ ml}.$$

S22. Let the mass of the solute is w gram and the volume of the solvent is V ml.

$$\therefore \quad \text{Molarity} = \frac{w/80}{V} \times 1000 = 3.2$$

$$\therefore \quad \text{Molarity} = \frac{w/80}{V \times 0.4} \times 1000 = \frac{3.2}{0.4} = \mathbf{8}.$$

S23.

$$\text{Molarity} = \frac{\text{Number of moles of methanol}}{\text{Volume in litres}}$$

$$\therefore \quad 0.25 = \frac{\text{Number of moles of methanol}}{2.5}$$

$\therefore$ Number of moles of methanol = $0.25 \times 2.5 = 0.625$

$\because$ Molecular weight of methanol (CH_3OH) = $12 + 4 \times 1 + 16 = 32$

$\therefore$ Mass (in grams) of methanol = Number of moles $\times$ Molecular weight

$= 0.625 \times 32 = 20\,\text{g}$

$$\therefore \quad \text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{20\,\text{g}}{0.793\,\text{kg L}^{-1}} = \frac{20\,\text{g}}{793\,\text{g L}^{-1}} = \mathbf{0.02522\,L}.$$

S24. 1000 ml of 0.001 M HCl solution contains $Cl^- = 0.001$

$$100 \text{ ml of } 0.001 \text{ M HCl solution contains } Cl^- = \frac{0.001 \times 100}{1000} = 1 \times 10^{-4} \text{ mole}$$

$$\text{No. of } Cl^- \text{ ions} = 6.022 \times 10^{23} \times 1.0 \times 10^{-4}$$

$$= \mathbf{6.022 \times 10^{19}}.$$

S25.

$$\text{Density of water} = 1 \text{ g mL}^{-1}$$

$$\text{Mass of 100 mL of water} = \text{Volume} \times \text{Density}$$

$$= 1000 \times 1 = 1000 \text{ g}$$

$$\text{Moles of water} = \frac{1000}{18} = 55.55$$

Now, 55.55 moles H_2O are present in 1000 ml or 1 L of water.

$\therefore$ Molarity = **55.55 M**.

S26. Given,

$$\text{Molarity } (M) = 0.15 \text{ M},$$

$$\text{Volume } (V) = 250 \text{ ml},$$

$$\text{Molar mass of } C_6H_5COOH \ (M_B) = 122 \text{ g mol}^{-1}$$

$$\text{Molarity } (M) = \frac{W_B \times 1000}{M_B \times V \text{ (in mL)}} \Rightarrow 0.15 \ M = \frac{W_B \times 1000}{122 \times 250}$$

$$W_B = \frac{0.115 \times 122 \times 250}{1000} = \mathbf{3.508 \text{ g}}.$$

S27. Given, Mass of solute (W_B) = 22 g, Mass of solvent = 122 g

Mass of solution = 144 g

$$\text{Mass \% of } (C_6H_6) = \frac{\text{Mass of Benzene} \times 100}{\text{Total mass of solution}} = \frac{22}{144} \times 100 = 15.27\%$$

$$\text{Mass \% of } CCl_4 = \frac{\text{Mass of } CCl_4 \times 100}{\text{Total mass of solution}} = \frac{122}{144} \times 100 = \mathbf{84.72\%}.$$

S28.

$$\text{Molecular mass of } CaCl_2 = 1 \times 40 + 2 \times 35.5 = 111 \text{ g mol}^{-1}$$

$$\text{Molality} = \frac{\text{No. of moles of the solute}}{\text{Mass of solvent in Kg}}$$

$$\text{Moles of } CaCl_2 \text{ in 1 Kg solvent} = 0.25 \times 1 = 0.25 \text{ mol}$$

$$\text{Mass of } CaCl_2 = \text{Moles of solute} \times \text{Molecular mass}$$

$$= 0.25 \times 111 = \mathbf{27.75 \text{ g}}.$$

We prepare 0.25 m $CaCl_2$ by dissolving 27.75 g $CaCl_2$ in 1 kg water.

S29.

$$\text{Normality} = \frac{\text{Gram eq. weight}}{\text{Volume of solution in Lit.}}$$

$$\text{Gram eq. weight} = \frac{\text{Given weight}}{\text{eq. weight}} \qquad \left(\text{eq. weight} = \frac{MW}{n} = \frac{98}{2}\right.$$

Basicity of H_2SO_4 = 2)

Hence, $$N = \frac{0.409 \times 1000}{49 \times 100} = \mathbf{0.083\ N}.$$

S30. $\because$ Normality = 0.02

$\therefore$ $$\text{Molarity} = \frac{0.02}{2} \qquad (\because \text{ Valency factor} = 2)$$

Moles of oxalic acid = Molarity × Volume (in L)

$\therefore$ $$\text{Moles of oxalic acid} = \frac{0.02}{2} \times \frac{100}{1000} = 0.001 \quad (\therefore \text{ Valency factor} = M \times V_1)$$

$\therefore$ Number of molecules of oxalic acid = $0.001 \times 6.023 \times 10^{23}$

$= \mathbf{6.023 \times 10^{20}}$.

S31.

$$N = \frac{\text{Equivalent moles of NaOH}}{V_{sol}\text{ (in L)}}$$

$\because$ Equivalent moles of NaOH = $\dfrac{2}{40}$

and Volume of solution = $\dfrac{800}{1000}$ L

$\therefore$ $$N = \frac{2 \times 1000}{40 \times 800} = \mathbf{0.0625}.$$

S32. $\because$ mEq of solute does not change on dilution

$\therefore$ mEq of H_2SO_4 (conc.) = mEq of H_2SO_4 (dil.)

$$0.1 \times 0.1 = N \times 1000 \qquad (\because \text{ mEq} = N \times V_{sol}\text{ N mL})$$

$$\boldsymbol{N = 10^{-5}}.$$

S33. (a) mEq of HCl = 100 × 0.1 = 10

mEq of NaOH = 50 × 0.25 = 12.5

Because HCl and NaOH neutralise each other with equal equivalents

mEq of NaOH left = 12.5 – 10 = 2.5

Volume of new solution = 100 + 50 = 150 mL

$\therefore$ $$N_{NaOH}\text{ left} = \frac{2.5}{150} = \mathbf{0.0167}.$$

(b) mEq of $H_2SO_4 = 100 \times 0.2 \times 2 = 40$ $(\because N = M \times \text{Valency})$

mEq of HCl $= 200 \times 0.2 \times 1 = 40$

$\therefore$ Total mEq of acid $= 40 + 40 = 80$

Total volume of solution = 300 mL

$$\therefore \quad N_{\text{Acid solution}} = \frac{80}{300} = \mathbf{0.267}.$$

S34. mEq of connectrated solution $= 1600 \times 0.2050 = 328$

Let after dilution volume becomes V mL.

mEq of diluted solution $= 0.20 \times V$

$$\therefore \quad 328 = 0.20 \times V$$

$$V = 1640 \text{ mL}$$

Thus, the volume of water used to prepare 1640 mL of 0.20 N solution = 1640 – 1600 = 40 mL.

S35. Given, H_2SO_4 is 93% weight by volume.

Let, Volume of solution of = 100 mL

So, Weight of H_2SO_4 = 93 gram

Weight of solution $= 100 \times 1.84 = 184$ g

Weight of water $= 184 - 93 = 91$ g

$$\text{Molality } (m) = \frac{W_2 \times 1000}{Mw_2 \times W_1} = \frac{93 \times 1000}{98 \times 91} = \mathbf{10.42}.$$

S36.

$$m = \frac{x_2 \times 1000}{x_1 \times Mw_1} = \frac{0.2 \times 1000}{0.8 \times 78} = 3.205 \text{ mole/kg}.$$

S37.

$$m = \frac{\chi_2 \times 1000}{\chi_1 \times Mw_1}$$

$$\chi_1 = 0.85, \qquad \chi_2 = 1 - 0.85 = 0.15$$

$$m = \frac{0.15 \times 1000}{0.85 \times 18} = 9.8$$

S38.

$$M = \frac{\%\text{ by weight} \times 10 \times d}{Mw_2}$$

$$6.9 = \frac{30 \times 10 \times d}{56}$$

$$d = \mathbf{1.288\ mL^{-1}}.$$

S39.

$$M_1V_1 + M_2V_2 = M_3V_3$$

$$0.01 \times 3.5 + 0.05 \times 1.5 = M_3 \times 5 \qquad (V_3 = V_1 + V_3 = 3.5 + 1.5 = 5)$$

$$M_3 = \mathbf{0.022}.$$

S40. **Molarity** is defined as the number of moles of a solute dissolve per litre of the solution whereas molality is defined as the number of moles of the solute dissolve per kg of the slovent.

Effect of temperature on molarity and molality: Molality is independent of temperature whereas molarity change with temperature because volume depends on temparature and the mass does not.

S41. (a) Given:

Weight of solute (W_B) = 30 gram

Volume of solution (V) = 4.3 L

$M_B(Ca(NO_3)_2 \cdot 2H_2O = 218$ g mol^{-1}

$$M = \frac{n_B \times 1000}{V\,(ml)}$$

$$R = \frac{n_B}{V\,(\text{in Lit.})} = \frac{30}{218 \times 4.3} = \mathbf{0.032}.$$

(b) Change the M by Chanve the volume for same solute is:

$$M_1 V_1 = M_2 V_2$$

$$0.5 \times 50 = M_2 \times 500$$

$$M_2 = \frac{0.5 \times 50}{500} = \mathbf{0.05\ M}.$$

S42. GIven:

10% (w/w) solution of glucose means 10 g glucosae dissolve in 100 g solution,

Mass of solution (W) = 100 g

Mass of solute (W_B) = 10 g

Mass of solvent (W_A) = 100 – 10 = 90 g

Molar mass of water (M_A) = 18

Molar mass of glucose ($C_6H_{12}O_6$) = 180 g mol^{-1}

$$\text{Mole of water } (n_{H_2O}) = \frac{90}{18}$$

$$\text{Mole of glucose } (n_{\text{glucose}}) = \frac{10}{180}$$

$$\text{Molality } (m) = \frac{W_B \times 1000}{M_B \times W_A} = \frac{10 \times 1000}{180 \times 90} = \mathbf{0.617\ m}$$

$$\text{Molarity (M)} = \frac{W_B \times 1000 \times d}{M_B \times W} \qquad \left[\because \quad \text{Density}(d) = \frac{\text{Mass (M)}}{\text{volume (V)}}\right]$$

$$= \frac{10 \times 1000 \times 1.2}{180 \times 100} = \mathbf{0.67\ M}$$

$$\text{Mole fraction of glucose } (\chi_{\text{glucose}}) = \frac{n_{\text{glucose}}}{n_{H_2O} + n_{\text{glucose}}} = \frac{\frac{10}{180}}{\left(\frac{10}{180} + \frac{90}{18}\right)} = \mathbf{0.01}$$

$$\text{Mole fraction of water } (\chi_{\text{water}}) = \frac{n_{H_2O}}{n_{H_2O} + n_{\text{glucose}}} = \frac{\frac{90}{80}}{\left(\frac{10}{180} + \frac{90}{18}\right)} = \mathbf{0.99}$$

or Mole fraction of water = (1 – mole fraction of glucose)

= (1 – 0.01) = **0.99**

S43. Glven:

$$\text{Weight of solute in solution I}^{\text{st}} = \frac{25 \times 300}{100} = 75 \text{ gram}$$

$$\text{Weight of solute in solution II}^{\text{nd}} = \frac{40 \times 400}{100} = 160 \text{ gram}$$

$$\text{Weight \% of mixture} = \frac{\text{Total weight of solute}}{\text{Total weight of solution}} \times 100$$

$$= \frac{75 + 160}{300 + 400} \times 100 = 22.57\% \text{ Solute}$$

$100 - 33.57$ = **66.43%** Solvent (H_2O)

S44. Glven:

Mass of ethylene glycol (W_B) $C_2H_4(OH)_2$ = 222.6 gram

Molar weight [$C_2H_4(OH)_2$] = 62 g mol^{-1}

Mass of H_2O (W_A) = 200 g

Molar mass (H_2O) = 18 g mol^{-1}

Density of solution (d) = 1.072 g mol^{-1}

Mass of solution (W) = 222.6 + 200 = **422.6 gram**

$$\text{Molality (M)} = \frac{n_B \times 1000}{W_A \text{ gram}}$$

$$= \frac{222.6 \times 1000}{62 \times 200} = \mathbf{17.95\ M}$$

$$\text{Molarity (M)} = \frac{n_B \times 1000}{V_{Ml}}$$

Or $$= \frac{n_B \times d \times 1000}{W} \qquad \left(d = \frac{W}{V}\right) \left(V = \frac{W}{d}\right)$$

$$M = \frac{222.6 \times 1.072 \times 1000}{62 \times 422.6} = \mathbf{9.1\ M}$$

S45. Given:

Weight of solute (W_B) = 2.5 g (K_2CO_3)

Molar weight of solute (M_B) = 138 g/mol

Volume of solution (V) = 1 Lit. = 1000 ml

density of solution (d) = 0.85 g/ml

$$M = \frac{n_B}{W_A} \times 1000$$

$$n_B = \frac{W_B}{M_B} = \frac{2.5}{138} = 0.018$$

$$W_A = W - W_B \qquad \left(d = \frac{W}{V}\right)$$

$$= d \times V - W_B \qquad (W = d \times V)$$

$$= 0.85 \times 1000 - 2.5$$

$$= 850 - 2.5$$

$$= 847.50$$

i.e., $$M = \frac{0.018}{847.50} \times 1000 = \mathbf{0.021\ molal}.$$

S46. Given:

Weight of solution (W) = 214.2 gram

Weight of solute (W_B) = 34.2 gram

Molar mass of sugar (M_B) = 342 g/mol

(i) Mol fraction (X_B)

$$X_B = \frac{n_B}{n_A + n_B}$$

$$n_B = \frac{\cancel{34.2}}{\cancel{342}} = 0.1$$

$$n_A = \frac{\cancel{180}}{\cancel{18}} = 10 \text{ (Solvent is water, } M_A = 18)$$

$$X_B = \frac{0.1}{10 + 0.1} = \frac{0.1}{10.1} = \mathbf{0.0099}.$$

(ii) $$\text{Molality (M)} = \frac{n_B \times 1000}{W_A}$$

Or $$M = \frac{n_B \times 1000}{(W - W_B)} \times 1000$$

$$M = \frac{34.2 \times 1000}{342\,(214.2 - 34.2)}$$

$$= \frac{0.1 \times 1000}{180} = \mathbf{0.55\ molal}.$$

S47. (a) **Calculation of molarity:**

Molar mass of oxalic acid, $(COOH)_2 \cdot 2H_2O$

$$= 2\,(12 + 32 + 1) + 2 \times 18$$

$$= 126\ \text{g mol}^{-1}$$

$$\text{Moles of oxalic acid} = \frac{0.63}{126} = 0.005\ \text{mol}$$

Volume of solution = 250 mL

$$\text{Molarity} = \frac{0.005 \times 1000}{250} = \mathbf{0.02\ M}.$$

(b) **Calculation of normality:**

$$\text{Equivalent mass of oxalic acid} = \frac{\text{Mol. mass of oxalic acid}}{\text{Basicity}}$$

$$= \frac{126}{2} = 63$$

$$\text{Gram equivalents of oxalic acid} = \frac{0.63}{63} = 0.01$$

$$\text{Normality} = \frac{\text{Gram equivalents of solute}}{\text{Volume of solution (in mL)}} \times 1000$$

$$= \frac{0.01}{250} \times 1000 = \mathbf{0.04\ N}.$$

S48. This can be calculated by using the formula:

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Vol. of solution (in mL)}} \times 1000$$

$$0.50 = \frac{\text{Moles of NaCl}}{250} \times 1000$$

$$\therefore \quad \text{Moles of NaCl} = \frac{0.50 \times 250}{1000} = \mathbf{0.125\ mol}$$

Gram molecular mass of NaCl = 23 + 35.5 = 58.5 g

$\therefore$ Mass of NaCl solution in grams = Moles of NaCl $\times$ Molecular mass

$$= 0.125\ 58.5 = \mathbf{7.3125\,g}.$$

S49. (a) **Calculation of molality of solution:**

Mass of glucose = 2.82 g

$$\text{Mole of Glucose} = \frac{2.82}{180} \text{ (Molar mass = 180)}$$

Mass of water = 30 g

$$\text{Molality} = \frac{\text{Moles of glucose}}{\text{Mass of water}} \times 1000$$

$$= \frac{2.82 \times 1000}{180 \times 30} = \mathbf{0.522\,m}.$$

(b) **Calculation of mole fraction:**

$$\text{Moles of glucose} = \frac{2.82}{180} = 0.0157$$

$$\text{Moles of water} = \frac{30}{18} = 1.67$$

$$\text{Mole fraction of glucose} = \frac{0.0157}{0.0157 + 1.67} = \mathbf{0.009}.$$

$$\text{Mole fraction of water} = \frac{1.67}{0.0157 + 1.67} = \mathbf{0.991}.$$

S50. (a) Number of moles of $Na_2S_2O_3$ in 1 litre of solution = 3

Molecular weight of $Na_2S_2O_3$ = 2 $\times$ 23 + 2 $\times$ 32 + 3 $\times$ 16 = 158

Weight of $Na_2S_2O_3$ in 1 litre of solution 3 $\times$ 158 = 474 g

Weight of 1 litre of solution = Density $\times$ Volume = 1.25 $\times$ 1000 = 1250 g

$$\therefore \text{Weight percentage of } Na_2S_2O_3 = \frac{\text{Weight of } Na_2S_2O_3 \text{ in grams}}{\text{Weight of solution in grams}} \times 100$$

$$= \frac{474}{1250} \times 100 = \mathbf{37.92\%}$$

(b) Weight of water in 1 litre solution = 1250 – 474 = 776 g

$$\text{Number of moles of water} = \frac{776}{18} = 43.11$$

$\therefore$ Mole fraction of $Na_2S_2O_3 = \dfrac{3}{3+43.11} = \mathbf{0.065}$.

(c) 1 mole of $Na_2S_2O_3$ gives 2 moles of Na^+ and 1 mole of $S_2O_3^{2-}$ in solution. The molarity of $Na_2S_2O_3$ is 3 M. Therefore, the molarity of Na^+ will be **6 M** and molarity of $S_2O_3^{2-}$ will be **3 M**.

S51. Let V mL of the stock solution is needed.

$\therefore$ Mass of the stock solution = $1.25 \times V$ g

$\therefore$ Mass of HCl in the stock solution = $1.25 \times V \times \dfrac{29.2}{100}$ g

$\therefore$ Number of moles of HCl in the stock solution = $\dfrac{\text{Mass in grams}}{\text{Molecular weight}}$

$$= \frac{1.25 \times V \times 29.2}{100 \times 36.5}$$

Number of moles of HCl in the dilute solution = Molarity × Volume in litres

$$= 0.4 \times 200 \times 10^{-3}$$

Since the number of moles of HCl in the stock solution and in the dilute solution is the same,

$$\therefore \quad \frac{1.25 \times V \times 29.2}{100 \times 36.5} = 0.4 \times 200 \times 10^{-3}$$

$$\therefore \quad V = \mathbf{8}.$$

S52. (a) $\because$ Equivalent of $Ca(OH)_2 = \dfrac{0.74}{74/2} \left(\text{Eq.} = \dfrac{W}{E}\right)$

Volume of solution = 5 mL

$$\therefore \quad N = \frac{0.74 \times 1000 \times 2}{74 \times 5} = 4$$

$$\therefore \quad M = \frac{N}{\text{Valency}} = \frac{4}{2} = 2$$

(b) Equivalent of $H_2SO_4 = \dfrac{1}{10} \times 2$ ($\because$ Eq = Mole × Valency)

Volume of solution = 500 mL

$$\therefore \quad N = \frac{2 \times 1000}{10 \times 500} = 0.4$$

$$M = \frac{0.4}{2} = 0.2$$

S53. (a)

$$M = \frac{\%\text{ by weight} \times 10 \times d}{Mw_2}$$

$$= \frac{86 \times 10 \times 1.787}{98} = \mathbf{15.68\ mol/L}.$$

(b)

$$M_1V_1 = M_2V_2$$

$$15.68 \times V_1 = 0.2 \times 1$$

$$V_1 = 0.01274\,\text{L} = 12.74\,\text{mL}$$

(c)

$$W_1 = \text{Weight of } H_2O$$

$$= \text{Weight o solution} - \text{Weight of solute}$$

$$= 100 - 86 = \mathbf{14\,g}.$$

$$m = \frac{W_2 \times 1000}{Mw_2 \times W_1}$$

$$= \frac{86 \times 1000}{98 \times 14} = \mathbf{62.\ 68\ mol/kg}.$$

Date: 14/10/2021

Q1. In a reaction $A + B_2 \longrightarrow AB_2$
Identify the limiting reagent, if an, in the following reaction mixture:
100 atoms of A and 100 molecules of B_2

Q2. In a reaction $A + B_2 \longrightarrow AB_2$
Identify the limiting reagent, if an, in the following reaction mixture:
2 moles of A and 3 moles of B_2

Q3. In a reaction $A + B_2 \longrightarrow AB_2$
Identify the limiting reagent, if an, in the following reaction mixture:
300 atoms of A and 200 molecules of B_2

Q4. A mixture of FeO and Fe_3O_4 is heated in air till its weight becomes constant. If the weight is increased by 5%, find the composition of the initial mixture. (Fe = 56, O = 16)

Q5. 8.0 g of pure manganese dioxide is heated with excess of hydrochloric acid and the gas liberated is passed in KI solution. What would be the weight of the iodine liberated?

Q6. How many grams of $Na_4P_2O_7$ can be obtained from 100 g of Na_2HPO_4?

Q7. Calculate the weight of iron which will be converted into its oxide by the action of 18 gm of steam. (Fe = 56, H = 1, O = 16)

Q8. Calculate the amount of water produced by the combustion of 16 g of methane.

Q9. A reaction of $KMnO_4$ and HCl produces 8 litres of chlorine at N.T.P. Find the amount of $KMnO_4$ used in this reaction.

Q10. How many litres of CO_2 at N.T.P. should be passed in line water [$Ca(OH)_2$] so that 25 grams of white precipitate of $CaCO_3$ is obtained?

Q11. What would be the weight of K_2CO_3 formed when 280 cm^3 of CO_2 at N.T.P. is passed in KOH solution?

Q12. Find the volume of carbon dioxide at N.T.P. obtained by heating 16.8 g of sodium bicarbonate. (Na = 23, H = 1, C = 12, O = 16

Q13. Find the volume of nitrogen at N.T.P. obtained by heating 16 g of ammonium nitrite. (N = 14, H = 1, O = 16)

Q14. What volume of carbon dioxide will be formed at S.T.P. as a result of combustion of 2 litres of ethane?

Q15. Find the volume of Cl_2 gas at N.T.P. required for complete reaction with 10 litres of H_2S gas at N.T.P.

Q16. In a reaction $A + B_2 \longrightarrow AB_2$
Identify the limiting reagent, if any, in the following reaction mixture:
2.5 moles of A and 4 moles of B_2

Q17. In a reaction $A + B_2 \longrightarrow AB_2$
Identify the limiting reagent, if an, in the following reaction mixture:
5 moles of A and 2.5 moles of B_2

Q18. 0.037 g of an alcohol, ROH, was added to CH_3MgI and the gas evolved measured 11.2 cm^3 at S.T.P. What is the molecular weight of ROH?

Q19. How many litres of oxygen at S.T.P. will be required to burn completely 2.2 g of propane?

Q20. Calculate the amount of carbon dioxide that can be produced when
(a) 1 mole of carbon is burnt in 16 g of dioxygen.
(b) 2 moles of carbon are burnt in 16 g of dioxygen.

Q21. Calculate the amount of calcium oxide required when it reacts with 852 gm of P_4O_{10}.

Q22. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction

$$4HCl(aq) + MnO_2(s) \longrightarrow 2H_2O(l) + MnCl_2(aq) + Cl_2(g)$$

How many grams of HCl reacts with 5.0 of manganese dioxide?

Q23. Find out the weight of hydrogen liberated when 18 g of water reacts with excess of sodium. (H = 1, O = 16)

Q24. 50.0 kg of $N_2(g)$ and 10.0 kg of $H_2(g)$ are mixed to produce $NH_3(g)$. Identify the limiting reagent and calculate the amount of $NH_3(g)$ formed.

Date: 14/10/2021

S1. According to the equation of the reaction:

The proportion $A : B_2$ = 1 atom of A : 1 molecule of B_2

= 1 mole of A : 1 mole of B_2

So, The proportion $A : B_2$ = 100 atoms of A : 100 molecule of B_2

= 1 atom of A : 1 molecule of B_2

None of the reagents is in excess. **There is no limiting reagent**.

S2. According to the equation of the reaction:

The proportion $A : B_2$ = 1 atom of A : 1 molecule of B_2

= 1 mole of A : 1 mole of B_2

So, The proportion $A : B_2$ = 2 moles of A : 3 moles of B_2

= 1 mole of A : 1.5 moles of B_2

B_2 is in excess. **A is the limiting reagent**.

S3. According to the equation of the reaction:

The proportion $A : B_2$ = 1 atom of A : 1 molecule of B_2

= 1 mole of A : 1 mole of B_2

So, The proportion $A : B_2$ = 300 atom of A : 200 molecule of B_2

= 1.5 atoms of A : 1 molecule of B_2

A is in excess. **B_2 is the limiting reagent**.

S4. $4FeO + O_2 \longrightarrow 2Fe_2O_3$

$4Fe_3O_4 + O_2 \longrightarrow 6Fe_2O_3$

Ans: FeO = 20.3% and Fe_3O_4 = 79.7%.

S5. $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

$Cl_2 + 2KI \longrightarrow 2KCl + I_2$

Ans: 23.356 g.

S6. $2Na_2HPO_4 \xrightarrow{\Delta} Na_4P_2O_7 + H_2O$

Ans: 93.66 g.

S7. $3Fe + 4H_2O \longrightarrow Fe_3O_2 + 4H_2$

Ans: 42 gm.

S8. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

Ans: 36 g.

S9. $2KMnO_4 + 16HCl \longrightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$

Ans: 22.57 g.

S10. $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

Ans: 5.6 litres.

S11. $2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$

Ans: 1.725 g.

S12. $2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$

Ans: 2.24 litres.

S13. $NH_4NO_2 \xrightarrow{\Delta} N_2 + 2H_2O$

Ans: 5.6 litres.

S14. $2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

Ans: 4 litres.

S15. $H_2S + Cl_2 \longrightarrow 2HCl + S$

Ans: 10 litres.

S16. According to the equation of the reaction:

The proportion $A : B_2$ = 1 atom of A : 1 molecule of B_2

= 1 mole of A : 1 mole of B_2

So, The proportion $A : B_2$ = 2.5 moles of A : 5 moles of B_2

= 1 mole of A : 2 moles of B_2

B_2 is in excess. **A is the limiting reagent**.

S17. According to the equation of the reaction:

The proportion $A : B_2$ = 1 atom of A : 1 molecule of B_2

= 1 mole of A : 1 mole of B_2

So, The proportion $A : B_2$ = 5 moles of A : 2.5 moles of B_2

= 2 moles of A : 1 mole of B_2

A is in excess. **B_2 is the limiting reagent**.

S18. The alcohol reacts with CH_3MgI as follows:

$$CH_3MgI + ROH \longrightarrow CH_4 + Mg(OR)I$$

Thus, 1 mole of ROH gives 1 mole of CH_4.

Volume of 1 mole of CH_4 is 22.4 litre (22400 cm^3) at S.T.P.

$\therefore$ Number of moles of $CH_4 = \dfrac{11.2}{22400} = 5 \times 10^{-4}$

$\therefore$ Number of moles of alcohol $= 5 \times 10^{-4}$

$\because$ Number of moles $= \dfrac{\text{Mass in grams}}{\text{Molecular weight}}$

$\therefore$ Molecular weight of alcohol $= \dfrac{0.037}{5 \times 10^{-4}} =$ **74 u**.

S19. Propane burns as follows:

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

Molecular weight of propane $= 3 \times 12 + 8 \times 1 = 44$

Number of moles of propane $= \dfrac{2.2}{44} = 0.05$

1 mole of propane reacts with 5 moles of oxygen.

Hence, number of moles of oxygen required $= 5 \times 0.05 = 0.25$

$\because$ Volume of 1 mole of a gas at S.T.P. = 22.4 litres

$\therefore$ Volume of 0.25 moles o oxygen at S.T.P. $= 0.25 \times 22.4$ litre = **5.6 litres**.

S20. (a) Number of moles of dioxyen $= \dfrac{\text{Mass in grams}}{\text{Molecular weight}} = \dfrac{16}{32} = \dfrac{1}{2}$

$$\underset{1\ \text{mole}}{C} + \underset{32\ \text{gram}}{O_2} \longrightarrow \underset{44\ \text{gram}}{CO_2}$$

According to the equation of the reaction, 32 gram of O_2 react with 1 mole of C to produce 44 gram of CO_2.

Therefore, 16 gram of O_2 react with 1/2 mole of C to produce **22** gram of CO_2.

(b) Number of moles of C = 2 and number of moles of dioxygen = 1/2

Obviously C is in excess and dioxygen is the limiting reagent.

Hence, number of moles of CO_2 formed s 1/2.

Hence, amount of CO_2 formed $= (1/2) \times 44 =$ **22 g**.

S21. CaO reacts with P_4O_{10} as follows:

$$6CaO + P_4O_{10} \longrightarrow 2Ca_3(PO_4)_2$$

$$\text{Molecular weight of } P_4O_{10} = 4 \times 31 + 10 \times 16 = 284$$

$$\text{Number of moles of } P_4O_{10} = 852/284 = 3$$

$$\text{Number of moles of CaO required} = 3 \times 6 = 18$$

$$\text{Molecular weight of Cao} = 40 + 16 = 56$$

$$\text{Mass of CaO required} = 18 \times 56 = \mathbf{1008\,g}.$$

S22. Molecular weight of $MnO_2 = 54.9 + 2 \times 16 = 86.9$

$$\text{Mass of 1 mole of } MnO_2 = 86.9\,g$$

$$\text{Molecular weight of HCl} = 1 + 35.5 = 36.5$$

$$\text{Mass of 4 moles of HCl} = 4 \times 36.5 = 146\,g$$

$\because$ 86.9 g MnO_2 reacts with 146 g of HCl

$\therefore$ 5.0 g MnO_2 will react with $\frac{146}{86.9} \times 5.0 = \mathbf{8.4\,g}$ of HCl.

S23. Sodium reacts with water as follows:

$$\underset{\phantom{2\text{ moles}}}{2Na} + \underset{2\text{ moles}}{2H_2O} \longrightarrow 2NaOH + \underset{1\text{ mole}}{H_2}$$

$$\text{Mass of 2 moles of } H_2O = 2 \times (2 \times 1 + 16) = 36\,g$$

$$\text{Mass of 1 mole of } H_2 = 2 \times 1 = 2\,g$$

$\because$ 36 g of water gives 2 g hydrogen

$\therefore$ 18 g of water will give $\frac{2}{36} \times 18 = \mathbf{1}$ g of hydrogen.

S24.

$$\underset{28\,g}{N_2(g)} + \underset{6\,g}{3H_2(g)} \longrightarrow \underset{34\,g}{2NH_3(g)}$$

$$28\,g \text{ of } N_2(g) \text{ react with } H_2 = 6\,g$$

$$1\,g \text{ of } N_2(g) \text{ react with } H_2 = \frac{6}{28}\,g$$

Therefore, $50{,}000\,g$ of $N_2(g)$ react with $H_2 = \frac{6}{28} \times 50{,}000\,g$

$$= 10714.286\,g$$

But, we have only 10,000 g of H_2

Hence, H_2 is limiting agent

Now,

$$\underset{28\,g}{N_2(g)} + \underset{6\,g}{3H_2(g)} \longrightarrow \underset{34\,g}{2NH_3(g)}$$

6 g of H_2 react with N_2 produce NH_3 = 34 g

$\therefore$ 1 g of H_2 react with N_2 produce $NH_3 = \frac{34}{6}$ g

Therefore, 10,000 g of H_2 react with N_2 produce $NH_3 = \frac{34}{6} \times 10,000$ g

= 56666.667 g

= 56.7 kg

Hence, 56.7 kg of NH_3 will be formed.

Date: 14/10/2021

Q1. Write the empirical formulafor each one of the following:
(a) C_6H_6 (b) $C_4H_8O_2$ (c) Na_2CO_3 (d) C_4H_{10}

Q2. A compound is composed of 74% C, 8.7% H and 17.3% N. Determine the empirical formula of the compound. If the molecular mass of the compound is 162, what is its molecular formula?

Q3. What is the percentage composition of each element is zinc-phosphte $Zn_3(PO_4)_2$? (Zn = 65.5, P = 31, O = 16)

Q4. An organic compound consists of 6.023×10^{23} carbon atoms, 1.8069×10^{24} hydrogen atoms, and 3.0115×10^{23} oxygen atoms. What is its simplest formula?

Q5. A 0.2075 g sample of an oxide of cobalt on analysis was found to contain 0.1475 g cobalt. Calculate the empirical formula of the Cobalt oxide. (Co = 59 amu)

Q6. The molecular mass of an iodide of tin (Sn) is 625.5 amu. What is the empirical formula of the substance? (I = 127, Sn = 118.5)

Q7. What is the simplest formula of the compound which has the following percentage composition: Carbon 80%, Hydrogen 20%? If the molecular mass is 30, calculate its molecular formula.

Q8. 2.746 gm of a compound gave on analysis 1.94 g of silver, 0.268 g of sulphur and 0.538 g of oxygen. Find the empirical formula of the compound. (At. masses: Ag = 108, S = 32, O = 16)

Q9. 0.1653 g alminium reacts completely with 0.652 g chlorine to form chloride of aluminium.
(a) What is the empirical formula of the compound?
(b) If molecular mass of the compound is 267 amu, calculate the molecular formula of the compound.

Q10. A welding fuel gas contains carbon and hydrogen only. Burning a small sample of it in oxygen gives 3.38 g carbon dioxide, 0.69 g of water and no other products. A volume of 10.0 L (measured at STP) of this welding gas is found to weigh 11.6 g. Calculate
(a) empirical formula (b) molar mass of the gas, and (c) molecular formula.

Q11. The elemental composition of a compound is 54.2% C, 9.2% H and 36.6% O. Determine the simplest formula (empirical formula). If the molar mass of the compound is 88 g mol^{-1}, what is its molecular formula?

Q12. A compound on analysis gave the following percentage compassion : Na = 14.31%, S = 9.97%, H = 6.22%, O = 69.5%.
Calculate the molecular formula of the compound on the assumption that all the hydrogen in the compound is present in combination with oxygen as water of crystallisation. Molecular mass of the compound is 322. [Na = 23, S = 32, N = 1 and O = 16]

Q13. An organic compound on analysis gave the following data : C = 57.82%, H = 3.6%, and the rest is oxygen. Its vapour density is 83. Find its empirical and molecular formula.

Q14. Butyric acid contains C, H, O elements. 4.24 mg sample of butyric acid is completely burnt in oxygen. It gives 8.45 mg of carbon dioxide and 3.46 mg of water. What is the mass percentage of each element? Determine the empirical and molecular formula of butyric acid if molecular mass of butyric acid is determined to be 88 u.

Q15. A compound has the following composition: Mg = 9.76%, S = 13.01%, O = 26.01%, H_2O = 51.22%. What is its empirical formula? [Mg = 24, S = 32, O = 16, H = 1]

Date: 14/10/2021

S1. (a) In the formula C_6H_6, the atomic ratio is C : H = 6 : 6 for which common factor is 6. Therefore, the empirical formula is CH.

(b) In $C_4H_8O_2$, the atomic ratio is C: H : O = 4 : 8 : 2, for which the common factor is 2. Therefore, the empirical formula is C_2H_4O.

(c) In Na_2CO_3, the atomic ratio is Na : C : O = 2 : 1 : 3. This is the simplest ratio of whole numbers. Therefore, empirical formula is the same as the molecular formula of the given compound.

(d) In C_4H_{10}, the atomic ratio is C : H = 4 : 10, for which the common factor is 2. Therefore, the empirical formula is C_2H_5.

S2. We shall show the calculation in the tabular form:

Element	*Percent*	*R.A.M*	*Relative number of atoms*	*Simple atomic ratio*
C	74	12	$74 \div 12 = 6.16$	$6.16 \div 1.23 = 5$
H	8.7	1	$8.7 \div 1 = 8.7$	$8.7 \div 1.23 = 7$
N	17.3	14	$17.3 \div 14 = 1.23$	$1.23 \div 1.23 = 1$

Atomic ratio = C : H : N = 5 : 7 : 1

$\therefore$ Empirical formula = C_5H_7N

Empirical formula mass = 5C + 7H + N = $5 \times 12 + 7 \times 1 + 14 = 81$

Molecular mass = 162

$$\text{Number of empirical units} = n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{162}{81} = 2$$

Molecular formula = Empirical formula $\times\ n$

$= (C_5H_7N) \times 2 = C_{10}H_{14}N_2$.

S3. Mw of $Zn_3(PO_4)_2 = 65.5 \times 3 + 2\,[31 + 16 \times 4]$

$= 196.5 + 2 \times 95 = 386.5$

$$\%\text{ of Zn} = \frac{196.5 \times 100}{386.5} = 50.84\%$$

$$\%\text{ of P} = \frac{62 \times 100}{386.5} = 16.04\%$$

$$\% \text{ of O} = \frac{128 \times 100}{386.5} = 33.12\%.$$

S4.

$$\text{Moles of C} = \frac{6.023 \times 10^{23}}{6.023 \times 10^{23}} = 1$$

$$\text{Moles of H} = \frac{1.8069 \times 10^{24}}{6.023 \times 10^{23}} = 3$$

$$\text{Moles of O} = \frac{3.0115 \times 10^{23}}{6.023 \times 10^{23}} = 0.5$$

$$C : H : O = 1 : 3 : 0.5 = 2 : 6 : 1$$

Empirical formula = C_2H_6O.

S5.

$$\text{Weight of O} = 0.2075 - 0.1475 = 0.06\,\text{g}$$

$$\text{Mol of Co} = \frac{0.1475}{59} = 0.0025$$

$$\text{Mol of O} = \frac{0.06}{16} = 0.003$$

$$\text{Simplest ratio of Co} = \frac{0.0025}{0.0025} = 1.0$$

$$\text{Simplest ratio of O} = \frac{0.003}{0.0025} = 1.5$$

Ratio of Co : O = 1 : 1.5 = 2 : 3.

Formula = Co_2O_3.

S6. Let the formula of iodide of Sn = SnI_x

Since the valency of Iodide = – 1

$\therefore$ $SnI_x = 118.5 + 127 \times x = 625.5$

Solve for x:

$\therefore$ $x = 4$

Formula = SnI_4.

S7. *Calculation of empirical formula:*

Element	***Percentage***	***At.***	***Relative no. of Moles***	***Simple ratio***	***Simplest Whole no. Ratio***
C	80	12	$\frac{18}{12} = 6.66$	$\frac{6.66}{6.66} = 1$	1
H	20	1	$\frac{20}{1} = 20$	$\frac{20}{6.66} = 3$	3

$\therefore$ Empirical formula is CH_3.

Calculation of molecular formula:

Empirical formula mass = $12 \times 1 + 1 \times 3 = 15$

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{30}{15} = 2$$

Molecular formula = Empirical formula $\times$ 2 = $CH_3 \times 2$ = $\mathbf{C_2H_6}$.

S8. *To calculate empirical formula:*

Element	***Percentage***	***At. Mass***	***Relative no. of Moles***	***Simple ratio***	***Simplest Whole no. Ratio***
Ag	1.94 g	108	$\frac{1.94}{108} = 0.0179$	$\frac{0.0179}{8.375 \times 10^{-3}}$ = 2.12	2
S	0.268 g	32	$\frac{0.268}{32}$ = 8.375×10^{-3}	$\frac{8.375 \times 10^{-3}}{8.375 \times 10^{-3}}$ = 1	1
O	0.538 g	16	$\frac{0.538}{16} = 0.0336$	$\frac{0.0336}{8.375 \times 10^{-3}}$ = 4.01	4

The empirical formula is $\mathbf{Ag_2SO_4}$.

S9. Given, 0.1653 g of Al = 0.652 g of chlorine

(a) 27 g of Al = $\frac{0.652}{0.1653} \times 27$ = 106.95 g of chlorine

Moles of chlorine = $\frac{106}{35.5}$ = 2.998 = 3

Therefore, formula = $AlCl_3$.

(b) $Mw = 267$ g

Empiricaial formula weight of $AlCl_3 = 27 + 3 \times 35.5 = 133.5$

$$n = \frac{Mw}{EFw} = \frac{267}{133.5} = 2$$

Molecular formula = $2 \times AlCl_3 = Al_2Cl_6$.

S10. (a) **Determination of empirical formula**

$$\text{Mole of C in 3.38 g } CO_2 = \frac{1 \times 3.38}{44} = 0.07681$$

$$\text{Mole of H in 0.690 g } H_2O = \frac{2 \times 0.690}{18} = 0.07667$$

Mole ratio = C : H = 0.07681 : 0.07667 = 1.002 : 1.000

$\therefore$ Empirical formula of compound = CH

Empirical formula molar mass = C + H = 12 + 1 = 13

(b) **Calculation of molar mas**

Mass of 10.0 L of the gas = 11.6 g

$$\therefore \quad \text{Mass of 22.4 L (= 1 mol) of the gas} = \frac{11.6 \times 22.4\ \text{L/mol}}{10.0\ \text{L}} = 25.984\ \text{g/mol}$$

Number of empirical formula units in one molecule

$$= \frac{\text{Molar mass}}{\text{Empirical formula molar mass}} = \frac{25.9841}{13} = 2.$$

(c) **Calculation of molecular**

Molecular formula = Empirical formula $\times$ Number of empirical formula units

$= (CH) \times 2 = C_2H_2$.

S11.

$$\text{Relative number of atoms} = \frac{\text{Percentage of the atom}}{\text{Relative atomic mass}}$$

$$\text{Relative number of C atoms} = \frac{54.2}{12} = 4.51$$

$$\text{Relative number of H atoms} = \frac{9.2}{1} = 9.20$$

$$\text{Relative number of O atoms} = \frac{36.6}{16} = 2.28$$

The atomic ratio is C : H : O = 4.51 : 9.20 : 2.28

On dividing each number of the ratio by the smallest number 2.28, we get

C : H : O = 1.98 : 4.03 : 1.00 = 2 : 4 : 1

The empirical formula = C_2H_4O

Empirical formula mass = $2 \times C + 4 \times H + 1 \times O$

$= 2 \times 12 + 4 \times 1 + 1 \times 16 = 44$

Empirical molar mass = 44 g mol^{-1}

Molar mass = 88 g mol^{-1}

$\therefore \quad n = \dfrac{\text{Molar mass of molecule}}{\text{Empirical molar mass}}$

$= \dfrac{88 \text{ g mol}^{-1}}{44 \text{ g mol}^{-1}}$

$\therefore$ Molecular formula = (Empirical formula) $\times n$

$= (C_2H_4O) \times 2 = \mathbf{C_4H_8O_2}$.

S12. *Calculation of empirical formula:*

Element	*Percentage*	*At. Mass*	*Relative no. of Moles*	*Simple ratio*	*Simplest Whole no. Ratio*
Na	14.31	23	$\frac{14.31}{23} = 0.62$	$\frac{0.62}{0.31} = 2$	2
S	9.97	32	$\frac{9.97}{32} = 0.31$	$\frac{0.31}{0.31} = 1$	1
H	6.22	1	$\frac{6.22}{1} = 6.22$	$\frac{6.22}{0.31} = 20$	20
O	69.5	16	$\frac{69.5}{16} = 4.34$	$\frac{4.34}{0.31} = 14$	14

$\therefore$ The empirical formula is $Na_2SH_{20}O_{14}$.

Calculation of molecular formula:

Empirical formula mass = $23 \times 2 + 32 + 20 \times 1 + 16 \times 14 = 322$

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{322}{322} = 1$$

Hence, molecular formula = $Na_2SH_{20}O_{14}$.

Since all hydrogen is present as H_2O in the compound, it means 20 hydrogen atoms must have combined with 10 atoms of oxygen to form 10 molecules of water of crystallisation. The remaining (14 – 10 = 4) atoms of oxygen should be present with the rest of the compound.

Hence, molecular formula = $\mathbf{Na_2SO_4 \cdot 10H_2O}$.

S13. *Calculation of empirical formula:*

Element	*Percentage*	*At. Mass*	*Relative no. of Moles*	*Simple ratio*	*Simplest Whole no. Ratio*
C	57.82	12	$\frac{57.82}{12} = 4.818$	$\frac{4.818}{2.4} = 2$	4
H	3.60	1	$\frac{3.60}{1} = 3.60$	$\frac{3.6}{2.4} = 1.5$	3
O	38.58	16	$\frac{38.58}{16} = 2.40$	$\frac{2.4}{2.4} = 1$	2

∴ Empirical formula is $C_4H_3O_2$.

Calculation of molecular formula:

Empirical formula mass = $12 \times 4 + 1 \times 3 + 2 \times 16 = 83$

Molecular mass = $2 \times$ V.D. = $2 \times 83 = 166$

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{166}{83} = 2$$

Molecular formula = Empirical formula $\times\, n$

$= C_4H_3O_2 \times 2 = C_8H_6O_4$.

S14. Mass of carbon present in 8.45 mg of CO_2 = $\frac{8.45 \times 12}{44}$ mg $= 2.30$

$$\text{Percentage of carbon} = \frac{2.30 \times 100}{4.24} = 54.24\%$$

$$\text{Mass of hydrogen in 3.46 mg of } H_2O = \frac{3.46 \times 2}{18} \text{ mg} = 0.384 \text{ mg}$$

$$\text{Percentage of hydrogen} = \frac{0.384 \times 100}{4.24} = 9.05\%$$

Percentage of oxygen = $100 - 54.24 - 9.05 = 36.71\%$

Element	*Percentage*	*At. Mass*	*Relative no. of Moles*	*Simple ratio*	*Simplest Whole no. Ratio*
C	54.24	12	$\frac{54.24}{12} = 4.52$	$\frac{4.52}{2.29} = 1.97$	2
H	9.05	1	$\frac{9.05}{1} = 9.05$	$\frac{9.05}{2.29} = 3.95$	4
O	36.71	16	$\frac{36.71}{16} = 2.29$	$\frac{2.29}{2.29} = 1$	1

∴ Empirical formula is C_2H_4O.

Calculation of molecular formula:

Empirical formula mass = $12 \times 2 + 1 \times 4 + 16 \times 1 = 44$

Molecular mass = 88 u

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{88}{44} = 2$$

Molecular formula = Empirical formula $\times$ n

$= C_2H_4O \times 2 = \mathbf{C_4H_8O_2}$.

S15.

Element	Percentage mass	At. Moles	Relative no. of	Simple ratio	Simplest Whole No. Ratio
Magnesium	9.76	24	$\frac{9.76}{24} = 0.406$	$\frac{0.406}{0.406} = 1$	1
Sulphur	13.01	32	$\frac{13.01}{32} = 0.406$	$\frac{0.406}{0.406} = 1$	1
Oxygen	26.01	16	$\frac{26.01}{16} = 1.625$	$\frac{1.625}{0.406} = 4$	4
Water	51.22	18 (mol. mass)	$\frac{51.22}{18} = 2.846$	$\frac{2.846}{0.406} = 7$	7

Hence, the empirical formula is **$MgSO_4 . 7H_2O$.**