MINISTRY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF TECHNICAL AND VOCATIONAL EDUCATION

Sample Questions & Worked Out Examples For

E.Sc 01011 ENGINEERING SCIENCE

A.G.T.I.(First Year)

Engineering Students

Part One

Chapter (1)

1. Define the terms:

Radioactivity : Radioactivity is a natural phenomenon that is spontaneous emission of radiation by mineral sources.

Isotopes : Two or more atoms having the same atomic number but different mass numbers are called isotopes.

Atomic mass :

$$\text{Atomic mass of an element} = \left[\text{mass of isotope (1)} \times \text{fractional abundance of isotope (1)}\right] + \left[\text{mass of isotope (2)} \times \text{fractional abundance of isotope (2)}\right]$$

A mole : A mole is the amount of substance that contains of a number of chemical units equal to the number of atoms in exactly 12 g of pure carbon-12.

2. Describe the characteristics of alpha, beta, gamma rays.

Alpha rays : Alpha rays are particles carrying two fundamental units of positive charge and having the same mass as helium atom.

Beta rays : Beta rays are negatively charged particles produced by changes occurring within the nuclei of radioactive atoms and have the same properties as electrons.

Gamma rays : Gamma rays are electromagnetic radiation of extremely high penetrating power.

3. Write an account for cathode rays.

In passing electricity through evacuated glass tubes, a type of radiation emitted by the negative terminal (cathode) that crossed the evacuated tube to the positive terminal (anode).

Cathode rays travel in straight line and have properties that are independent of the cathode material

Cathode rays are deflected by electric and magnetic fields.

Cathode rays are negatively charged fundamental particles of matter found in all atoms and becomes known as electrons.

4. What is the significan features of nuclear atom

- □ Most of the mass and all of the positive charge of an atom are centered in a very small region called the nucleus. The atom is mostly empty space.
- □ The magnitude of the positive charge is different for different atoms and is approximately one half the atomic weight of the element.
- □ There exist as many electrons outside the nucleus as there are units of positive charge on the nucleus. The atom as a whole is electrically neutral.

5. The two isotopes of ^{6}Li and $_{7}Li$ have masses of 6.01513 and 7.01601 u. The average atomic mass of lithium is 6.941 u.
(a) Which of these two isotopes is more abundant?
(b) Calculate the percent natural abundance of the two.

(a) Lithium (7) is more abundant because the weighted average atomic mass (6.941 u) is much closer to (7) than to(6).

(b)The fractional abundance of ^{6}Li isotope= (x)
----------------------------------^{7}Li isotope= (1 – x)

$$\text{Atomic mass of an element} = \left[\text{mass of isotope(1)} \times \text{fractional abundance of isotope(1)}\right] + \left[\text{mass of isotope (2)} \times \text{fractional abundance of isotope(2)}\right]$$

$$\begin{aligned} \text{Atomic mass of Li} &= [\,(x) \times 6.01513.u\,] + [\,(1-x) \times 7.01601\ u] \\ 6.941\ u &= 6.01513\ x + 7.01601 - 7.01601\ x \\ x &= 0.074944 \end{aligned}$$

The % abundance. of ^{6}Li isotope = 0.074944 x 100%

= 7,4944%

The % abundance. of ^{7}Li isotope = (100 - 0.074944) × 100% = 92.5056 %

6. The percent abundance of ^{40}K atom is 0.012%. How many ^{40}K atom do you ingest by drinking one cup of milk containing 371 mg of K? (K = 39.098)

$$(?)\ ^{40}\text{K atoms} = 371 \times 10^{-3}\ \text{g K} \times \frac{1\,\text{mol K}}{39.0983\ \text{g K}}$$

$$\times \frac{6.022 \times 10^{23}\,\text{atom K}}{1\ \text{mol K}} \times \frac{0.012\,\text{atom}\ ^{40}\text{K}}{100\,\text{atom K}}$$

$$= 6.8570 \times 10^{17}\ \text{atom}\ ^{40}\text{K}$$

7. What is the mass, in gram, corresponding to 1.000 u.?

$$(?)\ \ g = 1\,u \times \frac{1\ \text{atom}\ ^{12}C}{12\,u} \times \frac{1\ \text{mol}\ ^{12}C}{6.02 \times 10^{23}\ ^{12}C\ \text{atoms}} \times \frac{12\,g}{1\ \text{mol}}\frac{^{12}C}{^{12}C}$$

$$= 1.6605 \times 10^{-24}\ g$$

8. For the nulide $^{133}_{55}Cs$, express the percentage, by number of the fundamental particles in the nucleus that are neutrons.

Total particles in the nucleus = 133
No: of neutron in the nucleus = 133 – 55 = 78

(%)neutrons in the nucleus = $\frac{78}{133} \times 100\ \% = 67\%$

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Chapter (2)

1. What is meant by the following terms:

Electromagnetic radiation: Electromagnetic radiation is a form of energy transmission through a vacuum or medium in which electric and magnetic fields are propagated as wave.

Atomic Spectra : The spectra produced by certain gaseous substances consist of only a limited number of colored lines with dark spaces between them. These discontinuous spectra are called atomic spectra

Stationary States : The electron has only a fixed set of allowed orbits, called stationary states.

Pauli Exclusion Principle : No two electrons in an atom may have all four quantum numbers alike.

Hund's rule : When orbitals of identical energy are available, electrons initially occupy these orbitals singly.

2. How many quantum numbers are required to specify an electron in a single orbital and what are the values?

The four sets of quantum numbers.

(i) Principle Q.no. (n) $n = 1, 2, 3, \ldots\ldots n$
(ii) Orbital Q.no. (l) $l = 0, 1, 2, \ldots\ldots(n-1)$
(iii) Magnetic Q.no. (m_1) $(m_l) = +l \ldots 0 \ldots -l$
(iv) Spin Q.no. (n) $m_s = +\frac{1}{2}, -\frac{1}{2}$

3. What type of orbital is designated (a) n = 2, l = 1, (b) n = 4, l = 2. (c) n = 5, l = 0 ?

$n = 2,\ l = 1 \rightarrow 2p$
$n = 4,\ l = 2 \rightarrow 4d$
$n = 5,\ l = 0 \rightarrow 5s$

4. Calculate the energy emitted by the light of a sodium vapor lamp which has wavelength of 589 nm. (h = plank's constant = 6.626×10^{-34} J s, c = 2.998×10^{8} ms^{-1})

λ = 589 nm = 589×10^{-9} m

$$E = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\ \text{Js photon}^{-1} \times 2.998\times10^{8}\ \text{ms}^{-1}}{589\times10^{-9}\,\text{m}}$$

$= 3.3748\ \ 10^{-19}$ J / photon

5. How long does it take light from the sun 93 million miles away to the earth? c = 2.998×10^{8} ms^{-1}, (1 mile = 1.60931 km)

93 million miles = 93×10^{6} miles.

$$(?)\ \text{second} = 93 \times 10^{6}\ \text{miles} \times \frac{1.60931\ \text{km}}{1\text{mile}} \times \frac{10^{3}\,\text{m}}{1\text{km}} \times \frac{1\text{s}}{2.988\times10^{8}\ \text{m}}$$

= 499.2189 s

6. Calculate the velocity of a beam of photon moving with a wavelength of 10pm. mass of proton = 1.67×10^{-24} g, h = plank's constant = 6.626×10^{-34} kg m^{2} s^{-1})

λ = 10 pm = 10×10^{-12} m
m = 1.67×10^{-24} g = 1.67×10^{-27} kg

$$\lambda = \frac{h}{mv}$$

$$v = \frac{h}{m\lambda} = \frac{6.626\times10^{-34}\ \text{kg}\,\text{m}^{2}\ \text{s}^{-1}}{1.67\times10^{-27}\ \text{kg}\times10\times10^{-12}\ \text{m}}$$

v = 3.9676×10^{4} m s^{-1}

7. Calculate the wavelength of an alpha particles if its velocity is 1.5×10^{7} m s^{-1}. Avogadro's no, = 6.02×10^{23}, c = 2.998×10^{8} ms^{-1}, h = 6.626×10^{-34} kg m^{2}s^{-1}, (alpha particles = ${}_{2}^{4}He^{2+}$)

α particle = ${}_{2}^{4}He^{2+}$

molar mass of He = 4 g/mol

$$(?)\text{ g of one } \alpha \text{ particle} = \frac{4\text{g}}{1\text{mol}} \times \frac{1\text{mol}}{6.022\times10^{23}\ \text{particles}}$$

$$= 6.6423 \times 10^{-24} \text{ g / particles}$$

$$m = 6.6423 \times 10^{-24} \text{ g} = 6.6423 \times 10^{-27} \text{ kg}$$

$$\lambda = \frac{h}{mv} = \frac{6.626\times10^{-34}\ \text{kg m}^2\ \text{s}^{-1}}{6.6423 \times 10^{-27}\ \text{kg} \times 1.5\times10^{7}\ \text{ms}^{-1}} = 6.65 \times10^{-15}\,\text{m}$$

$$= 6.65 \times10^{-6}\ \text{nm}$$

8. The ionization energy of Na is 496 kJ mol^{-1}. What is the wavelength of a photon that will cause this ionization?

$$E = \frac{496\times10^{3}\ \text{J}}{1\ \text{mol}} \times \frac{1\text{mol}}{6.023\times10^{23}\ \text{photons}} = 82.3646\times10^{-20}\ \text{J / photon}$$

$$E = h\,\frac{c}{\lambda}$$

$$\lambda = \frac{hc}{E} = \frac{6.626\times10^{-34}\ \text{Js} \times 2.998\times10^{8}\ \text{ms}^{-1}}{82.3646\times10^{-20}\ \text{J}}$$

$$= 2.4118 \times 10^{-7}\ \text{m}$$

$$= 241.18\ \text{nm}$$

9. Describe four sets of quantum numbers <u>for a last added electron</u> of the following elements. State whether they are paramagnetic or diamagnetic.

$_{19}K$, $_{32}Ge$, $_{16}S$, $_{12}Mg$

	m	l	m_l	m_s
$_{19}K$ = [Ar] $4s^1$	4	0	0	$+\frac{1}{2}$
$_{32}$ Ge = [Ar] $4s^2$ $3d^{10}$ $4p^2$	4	1	0	$+\frac{1}{2}$
$_{16}S$ = [Ne] $3s^2$ $3p^4$	3	1	-1	$-\frac{1}{2}$
$_{12}Mg$ = [Ne] $3s^2$	3	0	0	$-\frac{1}{2}$

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Chapter (3)

1. **(a) Define the term ionization energy.**

(b) Are these any atoms for which the second ionization energy is larger than the first? Explain.

(a) The ionization energy is the quantity of energy a gaseous atom must absorb so that an electron is stripped from the neutral atom.

$Na_{(g)} \rightarrow Na^{+}_{(g)} + e^{-}$

(b) Second ionization energy is always greater than the first ionization energy, because the electron must be removed from a positively charged ions**.** The attraction between the positive ion and the electron is stronger than between the neutral atom and the electron.

2. **Compare the elements K and Ca with respect to the following properties,**
(a) Electron configuration
(b) Most common ionic charge
(c) First ionization energy
(d) Atomic radius.

	K	**Ca**
(a)	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$
(b)	+1	+2
(c)	K < Ca	
(d)	K > Ca	

3. **Arrange the following elements in order of inereasing their melting point**
(a) Na, Si, Al and Mg. (b) CBr_4, CCl_4, CH_4

(a) Na < Mg < Al < Si (b) CH_4 < CCl_4 < CBr_4

The larger the molecular mass, the stronger intermolecular forces, the higher the melting point.

4. **(a) Which one is better reducing agent, Mg or Al?**

(a) Al has lower ionization energy than Mg and thus is more easily oxidized. Therefore Al is better reducing agent.

(b) Which one is better oxidizing agent, Cl or Br?

(c) Cl has higher electron affinity than Br and thus is more easily reduced. Therefore Cl is better oxidizing agent.

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Chapter (4)

1.Explain the terms:

Limiting reactant.	The reactant that is completely consumed in a reaction is known as limiting reactant.
Theoretical yield	The calculated quantity of product in a chemical reaction is called theoretical yield of a reaction.
Consecutive reaction	Reactions that are carried out one after another in sequence to yield a final product are called consecutive reactions.
Simultaneous reaction.	In simultaneous reactions two or more substances react independently of each other in separate reactions occurring at the same time.
Strong electrolyte	Strong electrolyte is completely ionized in water solution, and the solution is a good electrical conductor.
Weak acid	Weak acid Acids that are incompletely (partially) ionized in aqueous solution are called weak acids.
Oxidizing agents	The substance that causes some other substance to be oxidized and itself reduced.

2. An alloy used in fabricating aircraft structures consist of 93. 7% Al and 6.3% Cu by mass. The alloy has a densily of 2. 85 g cm^{-3}. What volume of the Al-Cu alloy must be dissolved in an excess of $HCl_{(aq)}$ to produce 1 g H_2? If one assumes that all the Al, but none of the Cu. reacts with HCl(oq)
(H = 1, Al = 27).

$$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$$

$$(?)\ cm^3\ alloy = 1gH_2 \times \frac{1\,mol\ H_2}{2g\ H_2} \times \frac{2\,mol\ Al}{3\,mol\ H_2} \times \frac{27\,g\,Al}{1\,mol\ Al} \times \frac{100\,g\,alloy}{93.7\,g\,Al} \times \frac{1\,cm^3\ alloy}{2.85\,g\ alloy}$$

$$= 3.3434\ cm\ alloy.$$

3. If 470.2 L of NH_3 gas at STP is used in this reaction and percent yield of urea is 79.4 %. What mass of urea, in gram will be obtained?
$2NH_{3\,(g)} + CO_{2\,(g)} \rightarrow CO(NH_2)_{2\,(aq)} + H_2O_{(1)}$ (C = 12, O = 16, N = 14, H =1)

$$(?)\ g\ Urea = 470.2\,LNH_3 \times \frac{1\,mol\ NH_3}{22.4\,L\,NH_3} \times \frac{1\,mol\ Urea}{2\,mol\ NH_3} \times \frac{60\,g\ Urea}{1\,mol\ Urea}$$

$$= 629.73\,g\,Urea\ (Theoretical\,yield)$$

$$Percentage\ yield = \frac{Actual\,yield}{Theoretical\,yield} \times 100\%$$

$$Actual\ yield\ = \frac{629.73\ g \times 79.4\%}{100\%} = 500\ g\ of\ Urea$$

4. 34 % by mass $HCl_{,(aq)}$ has a density of 1.025 g/mL. What volume (mL) of this solution would be required to reaSct with 100mL of 0.265 M, $AgNO_3$.

(Cl = 35.5, H =1)

$$HCl_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + HNO_{3(aq)}$$

$$(?)\ mL\ HCl_{(aq)} = 100 \times 10^{-3}\ L\ AgNO_{3(aq)} \times \frac{0.265\,mol\ AgNO_3}{1L\,AgNO_{3(aq)}} \times \frac{1\,mol\,HCl}{1\,mol\,AgNO_3} \times$$

$$\frac{36.5\,g\,HCl}{1\,mol\,HCl} \times \frac{100\,g\,HCl_{(aq)}}{34\,g\,HCl} \times \frac{1\,mL\ HCl_{(aq)}}{1.025\,g\,HCl_{(aq)}} = 2.775\ mL\ HCl_{(aq)}$$

5. (a) What volume of solution must be evaporated from 650 mL of 0.0415 M solution to increase the concentration of exactly 0.2 M ?

$V_1 = 650$ mL $\quad$ $V_2 = ?$

$C_1 = 0.0415$ M $\quad$ $C_2 = 0.2$ M

$$C_1\ V_1 = C_1\ V_1$$

$$V_1 = \frac{650\,mL \times 0.0415\,M}{0.25\,M} = 134.88\,mL$$

volume of water evaporated = $V_1 - V_2$ = (650 – 134.88) mL = 515.12 mL.

(b) What volume of water (mL) must be added to prepare 250 mL of 0.5 M H_2SO_4 solution from 6M H_2SO_4 ?

$V_1 = ?$ $\quad$ $V_2 = 250$ mL

$C_1 = 6$M $\quad$ $C_2 = 0.5$ M

$C_1\ V_1 = C_2\ V_2$

$$V_1 = \frac{250\,mL \times 0.5\,M}{6\,M} = 20.83\,mL$$

volume of water added = $V_2 - V_1$ = (250 - 20.83) mL = 229.17 mL.

6. What is percent yield, if the reaction of 30 g P_4 and 90 g Cl_2 produes 85.6 g PCl_3 ? (P =31, Cl = 35.5)

$$P_{4\,(1)} + 6Cl_{2\,(g)} \rightarrow 4\ PCl_{3\,(1)}$$

Assuming that P_4 is the limiting reagent.

$$(?)\text{mol of } PCl_3 = 30\,g\,P_4 \times \frac{1\,mol\,P_4}{124\,g\,P_4} \times \frac{4\,mol\,PCl_3}{1\,mol\,P_4}$$

$$= 0.9676 \text{ mol } PCl_3$$

Assuming that Cl_2 is the limiting reagent.

$$(?)\text{mol of } PCl_3 = 90\,g\,Cl_2 \times \frac{1\,mol\;Cl_2}{71\;g\,Cl_2} \times \frac{4\,mol\;PCl_3}{6\;mol\,Cl_2}$$

$$= 0.8450 \text{ mol } PCl_3$$

When the smaller amount (0.8450 mol) of PCl_3 is formed, Cl_2 is completely consumed.

$\therefore$ Cl_2 is limiting reagent.

$$(?)\text{ g of } PCl_3 = 0.8450 \text{ mol } PCl_3 \times \frac{138\,g\,PCl_3}{1\,mol\,PCl_3} = 116.61\text{ g}$$

$$\%\,Yield = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

$$= \frac{85.6\text{ g}}{116.61\text{ g}} \times 100\%$$

$$= 73.4\ \%$$

7. (a) $VO^{2+} + MnO_4^{-1} \rightarrow VO^{+}_2 + Mn^{2+} + H_2O$ (in acid solution)

(ans:) $5VO^{2+} + MnO_4^{-1} + H_2O \rightarrow 5\,VO^{+}_2 + Mn^{2+} + 2\,H^{+}$

(b) $Cl_2 + OH^{-} \rightarrow Cl^{-} + ClO^{-}_3 + H_2O$ (in base solution)

(ans:) $3\,Cl_2 + 6\,OH^{-} \rightarrow 5\,Cl^{-} + ClO^{-}_3 + 3\,H_2O$

8. Write net ionic equation for the following reactions.

(a) **$MgCl_2 + NaOH \rightarrow$?**

$Mg^{2+}_{(aq)} + OH^{-}_{(aq)} \rightarrow Mg(OH)_{2(s)}$

(b) **$CuSO_4 + Na_2CO_3 \rightarrow$?**

$Cu^{2+}_{(aq)} + CO_3^{2-}_{(aq)} \rightarrow CuCO_{3(s)}$

(c) **$CaCO_3 + HCOOH \rightarrow$?**

$CaCO_{3\,(s)} + 2\ HCOOH_{(aq)} \rightarrow 2\ HCOO^-_{(aq)} + Ca^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

9. The titration of 50 mL. of a saturated solution of sodium oxalate. $Na_2C_2O_4$ requires 25.8 mL of 0.0214 M, $KMnO_4$. What mass of $Na_2C_2O_4$, in gram, would be present in 1 L of this saturated solution? (C = 12, O= 16, Na = 23)

$C_2O_4^{2-} + MnO_4^- + H^+ \rightarrow Mn^{2+} + H_2O + CO_2$ (not balance)

$$5\ C_2O_4^{2-} + 2\ MnO_4^- + 16\ H^+ \rightarrow 2\ Mn^{2+} + 8\ H_2O + 10\ CO_2$$

5 mol 2 mol

$$(?)\ g\ Na_2C_2O_4 = 25.8\,mL\ KMnO_4 \times \frac{0.0214\,mol\ KMnO_4}{1000\,mL KMnO_4} \times \frac{5\ mol\ Na_2C_2O_4}{2\,mol\ KMnO_4}$$

$$\times \frac{134\,g\ \ Na_2C_2O_4}{1\,mol\ Na_2C_2O_4} = 0.1849\ \ g \quad \text{in 50 mL}$$

$$(?)\ g\,/L\ Na_2C_2O_4 = \frac{0.1849\,g}{50\,mL} \times \frac{1000\ mL}{1\,L} = 3.6992\ g/L$$

Chapter (5)

1. Deseribe any the assumptions of Kinetic molecular Theory of gases.

- A gas is composed of a very large number of extremely small particles (molecules or atoms) in constant, random, straight-line motion.
- Molecules of a gas are separated by great distances. The gas is mostly empty space.
- Molecules collide with one another and with the walls of their container.
- There are assumed to be no forces between molecules except very briefly during colliding.
- Individual molecules may gain or lose energy as a result of collisions. In a collision of molecules at constant temperature, however, the total energy remains constant.

2. Explain the following terms:

(a) **diffusion (b) effusion**

□ Diffusion is the migration of molecules of different substances as a result of random molecular motion.

□ Effusion is the escape of gas molecules from their container through a tiny hole.

3. A mixture of 4 g of H_2 and unknown quantity of He(g) is maintain at STP. If 10 g of H_2 is added to the mixture while conditions are maintained at STP. The volume of the gas is double. What mass of He(g) is present in the mixture? (He = 4. H = 1)

□ Let mol of He (initial) = x mol

$$(?) \text{ mol } H_2 \text{ (initial)} = 4 \text{ g } H_2 \text{ x } \frac{1 \text{mol} H_2}{2 \text{ g} H_2} = 2 \text{mol } H_2$$

$$(?) \text{ mol } H_2 \text{ (added)} = 10 \text{ g } H_2 \text{ x } \frac{1 \text{mol} H_2}{2 \text{ g} H_2} = 5 \text{mol } H_2$$

n_1 = (x + 2) mol $V_1 = V$

n_2 = (x + 7) mol $V_2 = 2V$

By Avogadro's theory ($V \propto n$)

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

$$\frac{(x+2)}{(x+7)} = \frac{1V}{2V}$$

x = 3 mol (He)

$$(?) \text{ g He} = 3 \text{ mol He x } \frac{4 \text{ g He}}{1 \text{mo He}} = 12 \text{ g He}$$

4. A 1.072 g sample of He(g) is found to occupy a volume of 8.446 L when collected over hexane at 25°C and 738.6 mmHg pressure. Determine the vapour pressure of hexane at 25°C, in mm Hg. (He = 4, R = 08205 L atom mol^{-1} K^{-1}).

T = 25°C + 273 = 298 K

$$M = \frac{mRT}{PV}$$

$$P_{He} = \frac{m\,R\,T}{M\,V} = \frac{1.072\,g \times 08205\,L\,atom\,mol^{-1}\,K^{-1} \times 298\ K}{4\,g\,mol^{-1} \times 8.446\,L} = 0.7758\ atm$$

$= 589.6$ mmHg

$P_{total} = P_{He} + P_{hexane}$

$P_{hexane} = (\,738.6\ - 589.6\,)$ mmHg $=\ 149$ mmHg

5. What mass of sodium azide must be dccomposed to produce 1 L of N_2(g) at 25°C

and 751 mmHg? $\quad 2NaN_{3\,(s)} \rightarrow 2Na_{\,(s)} + 3N_{2\,(g)}$

$$T = 25C + 273 = 298\ K \quad P = 751\ mm\ Hg\ \ x\ \frac{1\,atm}{760\,mm\,Hg} = 0.9882\,atm$$

PV = nRT

$$n = \frac{PV}{RT} = \frac{0.9882\ \ atm \times 1\,L}{08205\,L\,atom\,mol^{-1}\,K^{-1} \times 298\ K}$$

$= 0.0404$ mol N_2

$$(?)\ \ Na\,N_3 = 0.0404\ \ mol\ \ N_2 \times \frac{2\,mol\ \ NaN_3}{3\,mol\,N_2} \times \frac{65\,g\,NaN_3}{1\,mol\,Na\,N_3} = 1.75\,g$$

6. The mass of 1.2 L of a gas sample measured at 35°C and 754 mm Hg is 2.079 g. What is the root mean square velocity of this gas ?

($R = 8.3145\ kg\ m^2\ s^{-2}\ mol^{-1}\ K^{-1}$, $\quad R = 0.08205\ L\ atom\ mol^{-1}\ K^{-1}$).

T = 35 °C+ 273 = 308 K

$$P = 754\,mm\ \ Hg \times \frac{1\,atm}{760\,mm\ \ Hg} = 0.9921\ atm$$

$$M = \frac{mRT}{PV} = \frac{2.079\,g \times 0.08205\,L\ \ atm\ mol^{-1}\ \ K^{-1} \times 308\,K}{0.9921\ atm \times 1.2\ L} = 44.13\ \ g\ \ mol^{-1}$$

$$U_{\,rms} = \sqrt{\frac{3\ RT}{M}} = \sqrt{\frac{3 \times 8.3145\,kg\,m^2\ s^{-2}\ mol^{-1}\ K^{-1}\ \ \times 308\,K}{44.13\ \ g\ \ mol^{-1}}} = 417.24\,ms^{-1}$$

7. Suppose we put a cotton plug saturated with HCl solution into one end of 1 meter tube and simultaneously insert a plug saturated with aqueous NH_3 into the other end. How many centimeters from HCl end of the tube will white smoke first form ? (N = 14, H = 1 , Cl = 35.5)

Let, distance from HCl = a cm **Molar mass of NH_3 = 17 g / mol**

Distance from NH_3 = (100-a) cm **Molar mass of HCl = 36.5 g / mol**

$$\frac{\text{distance from HCl}}{\text{distance from } NH_3} = \sqrt{\frac{M_{NH_3}}{M_{HCl}}}$$

$$\frac{a}{(100-a)} = \sqrt{\frac{17\,g\,mol^{-1}}{36.5\,g\,mol^{-1}}} = 0.6824$$

$$a = 40.56 \text{ cm}$$

8. Calculate the pressure exerted by 1 mol of $CO_{2\,(g)}$ confined to a volume of 855 cm^3 at 30°C, Use (a) ideal gas equation and (b) the vander waals equation (c) compare the results and explain.

($a = 3.5\ L^2$ atom mol^{-2}) ($b = 0.0427\ L\ mol^{-1}$)

(a) PV = nRT

$$P = \frac{nRT}{V} = 29.0\,atm$$

(b) $(P + \frac{n^2}{V^2}a)(V - nb) = nRT$ (vander Waal's equation)

$$P = \frac{nRT}{V - nb} - \frac{n^2 a}{V^2}$$

$$P = 25.8 \text{ atm}$$

(c) The lower pressure calculated by vender Waal's equation is the result of the intermolecular attraction between the real gas molecules.

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Chapter (6)

1. Describe briefly the meaning of: surface tension, normal boiling point, enthalpy of vaporization, the critical point.

2. Equilibrium is established between $Br_{2\ (1)}$ and $Br_{2\ (g)}$ at 25C. A 250 cm^3 sample of the vapor weights 0.486 g. What is the vapor pressure of bromine at 25°C, in mmHg? (Br = 79.9)

3. Which of the following molecules can be liquefied at room temperature (about 25°C) ?
O_2 (Tc = 154. 8 K), CO_2 (Tc = 304.2 K). SO_2 (Tc = 431K)

4. Cyclohexanol used in the manufacture of nylon, has a vapor pressure of 10 mmHg at 56°C and 100 mmHg at 103.7°C. Calculate (a) ΔH_{vap} and (b)normal boiling point. (R = 8.3145 J mol^{-1} K^{-1})

5. What are the differences between cohesive forces and adhesive forces?

6. What type of intermolecular attractions are present in each of the following molecules? NH_3, Ar, HBr, CH_3NH_2, Zn, LiBr, CH_3OH.

7. What is meant by the terms instantaneous dipole and induced dipole?

8. Which of the following molecules have the higher boiling point?
Explain (i) He (or) Ne (ii) n-pentane (or) neo-pentane.

9. Which one of the following substance is a liquid at room temperature?
Give explanation. CH_3OH, C_3H_8, N_2, CO

10. All electrons in diamond are localized, but that in graphite certain electrons are delocalized.
(a) Explain the meaning of localized and delocalized.
(b) Which electrons in graphite are delocalized.

11. Which member of each pair is more soluble in CCl_4. (Give a brief reason)

(i) CH_3OH (or) $CHCl_3$

(ii) I_2 (or) HI

(iii) NH_3 (or) CH_4

(iv) C_6H_6 (or) $C_6H_4(OH)_2$

12. Draw the following cubic system and describe the no. of particles (atoms) per unit cell.

(i) CH_4 (or) CH_3OH

(ii) N_2 (or) NH_3

(iii)$CaCl_2$ (or) CCl_4

(iv)CH_3CH_2OH (or) CH_3OCH_3

13. Draw the following cubic system and describe the no. of particles (atoms) per unit cell.

(a) Simple cubic

(b) Body – centered cubic

(c) Face-centered cubic

14. K crystallize in a BCC unit cell measuring 0.533 nm on the edge. What is the radius of K atom.

15. Ba has a density of 3.5 g/cm^3 and crystallized in n BCC. Calculate the radius of Ba atom. (Ba = 137)

16. The first order reflection of X-rays of wavelength 0.154nm from a nickel crystal occurs at an angle of 12°40'. What is the distance between the plane atoms diffracting this X- ray beam ?

17. Density of lithium is 0.534 g / cm^3. The length of unit all measures 0.346 nm on an edge. What is the cubic crystal system occupied by lithium? (Li = 7)

18. (a) What is meant by the term crystal coordination number.

(b) Describe the coordination number of following.

Mg, Cu, Na

19. Explain the structure of ice crystal lattice and why water is denser than ice.

20. Write an account on liquid crystal.

Chapter (7)

1. Which of the following compounds are mostly ionic and which are mostly covalent. KH, H_2S, $SiCl_4$, Cr_2O_3

2. (a) Define, Covalent radius, Polar covalent bond.

(b) Indicate which of the following bond have the greatest bond length. And shortest bond length.

O_2, N_2, Br_2, BrCl

3. Explain why the incomplete octed of BF_3 is found generally.

4. Alghough PCl_5 is a known compound, NCl_5 is not. What reason can you offer for the failure to observe NCl_5 ?

5. What is meant by the terms.
(i) Valence electron (ii) Resonance

6. Draw the Lewis structure for
N_2F_2, HNO_3, $SOCl_2$, F_3SN, I_3^-, CS_2, PF_5, XeF_4, C_2H_4

7. Explain the electron pair repulsion theory with suitable example.

8. Predict the shape of the following molecules and ions.
NH^-_2, BH_3, H_2O^+, IF_5, $POCl_3$, SiO_4

9. Calculate the ionic character of H_2O. It's dipolement is 1.84 D and bond length is 0.095 nm. 1 D = 3.34×10^{-30} °C.m. (full ionic charge = 1.6×10^{-19}C)

10. Discuss the nature of covalent bond in HF molecule by using experimental data. (μ = 1.91 D, d = 0.092nm)

11. Percent ionic character of HF molecule is 43%. It's dipolement is μ = 1.9 D.

12. Estimate the C-H bond energy using a bond energy of 436 kJ mol^{-1} for H_2 and the reaction scheme outlined below.

$$C_{(g)} + 2H_2(g) \rightarrow CH_{4(g)} \qquad \Delta H_{rxn} = -792 \text{ kJ}$$

13. Enthapy of formation of H_2O_2 is- 136 kJ mol^{-1}, Estimate the O to O single bond energy.

Bond energies for

H-H	⇒	436 kJ mol^{-1}
O = O	⇒	498 kJ mol^{-1}
H-O	⇒	464 kJ mol^{-1}

14. Calculate the enthalpy of formation of methanol (CH_3OH)

$$CH_{4\,(g)} + H_2O_{\,(g)} \rightarrow CH_3OH_{\,(g)} + H_{2\,(g)} \qquad \Delta H_{rxn}\text{- ?}$$

Bond energies

C – H	414	kJ mol^{-1}
O– H	464	kJ mol^{-1}
H – H	436	kJ mol^{-1}
C – O	360	kJ mol^{-1}

15. Explain the terms.
(i) valence band (ii) conduction band

16. How does the electron sea model Explain. ?
- **(i) The deformation of metals?**
- **(ii) Electrical conductivity of metals?**
- **(iii) Lustrous appearance of metals?**

Chapter 8

1. What mass of H_2SO_4 is contatned in 25g of 15% by mass solution?
2. What is the molality of 20% by mass of H_2SO_4?
3. 14.8 M aqueous ammonia solution has a density of 0.898 g/mL. What is X_{NH3} is this solution. (N = 14, H = 1)
4. What is the molarity of 10 % by mass H_2SO_4 solution having a density of 1.07 g/ mL?
5. What mass of water must be added to 1 kg of 1.12 m CH_3OH (aq:) to reduce the malality to 1.00 m $CH_3OH_{(aq:)}$.
6. Define: Henry's Law
At 0°C and an O_2 pressure of 1.00 atm, the aqueous solubility of $O_{2(g)}$ is 48.9 mL O_2 per liter. What is the molarity of O_2 is a saturated water solution when the O_2 is under its nonmal partial pressure in air, 0.2095 atm?

7. Calculate the mole fraction of solute in the following aqueous solution.
(C = 12, H = 1, O = 16, N = 14)
(a) 13.2 % C_2H_5 OH by mass
(b) 0.512 m urea CO $(NH_2)_2$

8. Calculate the vapor pressure of solution at 25°C containing 26.9 g of Urea $CO(NH_2)_2$ is 712 g H_2O. (Vapor pressure of water at 25°C is 23.8 mmHg)
(N =4, H = 1, O = 16, C = 12)

9. An aqueous solution that is 0.205 m urea is formed to boil at 100.025°C. (Kg = 0.512°C m4). Is the actual atmospheric pressure above or below 760 mmHg?

10. 1.2 g sample of an unknown covalent compound is dissolved in 50 g of benzene and the solution freezes at 4.92°C. Determine molar mass of the compound. (K_f = 5.12°C)

13. An osmotic pressure of 3.56 mmHg is measured for 0.288 g of protein in 25 mL of solution at 25°C. What is the molar mass of the protein?

Chapter 9

1. Identify acid or base for each of the species in the following forward and reverse reactions.

(a) $H_2O + OCl^-$ ⇋ $HOCl + OH^-$

(b) $H_2PO_4^- + NH_3$ ⇋ $NH_4^+ + HPO_4^{2-}$

2. If 535 ml of gaseous HCl, at 26.5°C and 747 mmHg is dissolved in water to prepare 625 mL of solution. What is the pH of this solution.
(R = 0.0812 L atm mol^{-1} K^{-1})

3. Calcualte the pH of KOH solution that is 3% by mass KOH and has a density of 1.0242 g mL^{-1}. (K = 39, O = 16, H = 1)

4. Calculate the pH of a buffer solution containing.
(a) 0.1 M. methanoic acid and 0.01 M sodium methanoate. (Ka = 1.8 × 10^{-5})
(b) 0.15. acetic acid and 0.5 M CH_3COONa. (Ka = 1.7 × 1^{-5})

5. What mass of CH_3COONa must be dissolved in 0.3L of 0.25 M, CH_3COOH to produce a solution pH = 5.1 .
(Ka = 1.74 x 10^{-5}) (C = 12, H = 1, O = 16, Na = 23)

6. Cocaine ($C_2H_{22}O_4N$) is an alkaloid, that is soluble in water to the extent of 0.17 g / 100 mL. pH of this solution is 10.08. What is the value of K_b for cocaine.

7. The solubiliry of certain metallic hydroxide $M(OH)_3$ is 1.0 x 10^{-5} mol L^{-1} Calculate the K_{sp} of M $(OH)_3$.

8. The solubility of silver carbonate at 25°C is 1.16×10^{-1} M. Calculate the solubility product of that compound.

9. Lead (II) iodide saturated solution, its K_{sp} is 7.1 × 10^{-9} at 25°C. Calculate the solubility of PbI_2 ?

Chapter 10

1. 0.001 mole of sample of S_2 (g) dissociate in 0.5 L flask at 1000K.At equilibrium, 1 × 10-11 mole S (g) is present. What is Kc and Kp?

$S_{2\,(g)}$ ⇋ $2S_{(g)}$

2. What is the percent dissociation of N_2O_4(g) f 1.5 mole of N_2O_4(g) is introduced into a evacurated 2.5 L vessel at 25C ?

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \quad Kc = 4.61\times 10^{-3}.$$

3. The endothermic reaction $A_{(g)} + B_{(g)} \rightleftharpoons 2C_{(g)}$ proceed to the equilibrium condition at 200°C. Which of the following statements are true?

(a) If the mixture is transferred to a reaction vessel of twice the volume. The concentration of reactants and products will remain unchanged.
(b) Addition of B will result in the formation of a greater amount of C(g).
(c) Lowering the reaction temperature to 100C will result in the formation of a greater amount of C (g).

4. ! g {C;5 os omtrpdiced omtp a 250 mL tlask and it is heated to 300C, where the following equilibrium establish. PCls(g) $\rightleftharpoons$ PCl3(g) + Cl2(g)

The quantity of Cl2 present at equilibrium is found to be 0.25g. What is the value of Kc for the dissociation reaction at 300C? (P = 31, Cl = 35.5)

5. Describe the relationship between Kc and Kp.

Chapter 6

2. $Br_{2\,(l)} \rightleftharpoons Br_{2\,(g)}$

$V = 250\ cm^3 = 0.25\ L$

$m = 0.486\ g$

$M = 79.9\ g/mol$

$T = 273 + 25^{o}C = 298\ K$

$$PV = \frac{m}{M}RT$$

$$P = \frac{mRT}{MV} = \frac{0.486\ g \times 0.08206\ L\ atm\ mol^{-1}\ K^{-1} \times 298\ K}{79.9\ g/mol \times 0.25\ L}$$

$= 0.5949\ atm$

$= 452.718\ mm\ Hg$

3. A gas can be liquefied only at temperature below its critical temperature, T_c.

Room temp = $25^{o}C = 298\ K$

O_2 ($T_c = 154.8\ K$) cannot be liquefied because room temperature is above T_c.

CO_2 ($T_c = 304.2\ K$) can be liquefied because room temperature is below T_c.

4. (a) $P_1 = 10\ mm\ Hg$ $\quad T_1 = 56^{o}C + 273 = 329\ K$

$P_2 = 100\ mm\ Hg$ $\quad T_2 = 103.7^{o}C + 273 = 376.7\ K$

$R = 8.3145\ Jmol^{-1}K^{-1}$ $\quad \Delta H_{vap} = ?$

$$\ln\frac{P_2}{P_1} = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\ln\frac{100}{10} = \frac{\Delta H_{vap}}{R}(3.849 \times 10^{-4})$$

$$2.3025 = \frac{\Delta H_{vap}}{8.3145\ Jmol^{-1}K^{-1}}(3.849 \times 10^{-4})\ K^{-1}$$

$\Delta H_{vap} = 49.7397\ kJmol^{-1}$

(b) $P_1 = 10$ mm Hg $T_1 = 56^oC + 273 = 329$ K

$P_2 = 760$ mm Hg $T_2 = ?$

(for normal boiling point)

$R = 8.3145\ Jmol^{-1}K^{-}$

$\Delta H_{vap} = 49739.7\ Jmol^{-1}$

$$\ln\frac{760}{10} = \frac{49739{,}7\ Jmol^{-1}}{8.3145\ Jmol^{-1}K^{-1}}\left(\frac{1}{329} - \frac{1}{T_2}\right)K^{-1}$$

$$4.33 = 5982.3\ K\ (3.849 \times 10^{-3} - \frac{1}{T_2})$$

$T_2 = 431.84$ K

$T_2 = 158.8$ K (normal boiling point of cyclohexanol)

6. NH_3 = Hydrogen bond + London forces

Ar = London force only

HBr = dipole-dipole attraction + London forces

Zn = Metallic bond

LiBr= Electrostatic attraction

8. (i) **<u>He (or) Ne</u>**

- Both substances are non-polar.
- Ne has higher molecular mass and greater polarizability.
- ∴ Ne has stronger dispersion forces and higher boiling point than He.

(ii)

<u>n-pentane</u>	<u>neo-pentane</u>
Elongated molecule	Small, compact, symmetrical molecule

Electrons in elongated molecules are more easily displaced than symmetrical molecule and more polarizable and have greater dispersion forces. ∴ n-pentane has higher boiling point than neo-pentane.

9. CH_3OH = Hydrogen bond and dipole-dipole attraction

N_2, C_3H_8 = London force

CO = dipole-dipole attraction

More stronger intermolecular attraction corresponds to liquid state at room temperature.

10. See Pg.61, 62

11. (i) CH_3OH is more polar.

$CHCl_3$, less polar, will be soluble in non-polar CCl_4..

(ii) I_2 is non-polar that is similar to CCl_4.

I_2 is more soluble in non-polar I_2 is CCl_4.

(iii) NH_3 is polar. CH_4 is more soluble likely to non-polar CCl_4.

(iv) $C_6H_4(OH)_2$ is polar. C_6H_6 is more soluble because it is non-polar likely t CCl_4.

12. (i) CH_3OH is more soluble because it can form hydrogen bond with water.

CH_4 is non-polar that is unable to form hydrogen bond with water.

(ii) NH_3 more soluble because it can form hydrogen bond with water.

N_2 is non-polar that is unable to form hydrogen bond with water.

(iii) $CaCl_2$ is more soluble due to it's ionic dipole.

CCl_4 is non-polar and cannot dissolve in water.

(iv) CH_3CH_2OH is more soluble because it can form hydrogen bond with water.

(v) CH_3COCH_3 is non-polar that is unable to form hydrogen bond with water.

13. See pg.65.

14. K is BCC unit cell.

For BCC $4r = l\sqrt{3}$

$$r = \frac{0.533 \text{ x } \sqrt{3}}{4} = 0.2308 \text{ nm}$$

15. $$cm^3/\text{unit cell} = \frac{1\,cm^3}{3.5g} \times \frac{137\,g}{1\,mol} \times \frac{1\,mol}{6.02 \times 10^{23}\,atoms} \times \frac{2\,atoms}{1\,unit\,cell}$$
$$= 1.3 \times 10^{22}\,cm^3/\text{unit cell}$$

$$\text{Length of the unit cell} = (1.3 \times 10^{-22}\,cm^3)^{1/3}$$
$$= 5.066 \times 10^{-8}\,cm$$
$$= 0.5066\,nm$$

For BCC $\quad 4r = l\sqrt{3}$

$$r = \frac{0.5066 \times \sqrt{3}}{4} = 0.2194\,nm$$

16. $\lambda = 0.154\,nm$

$\theta = 12°40'$

$d = ?$

1 st : order = n = 1

$$n\lambda = 2d\,Sin\theta$$
$$d = \frac{n\lambda}{2\,Sin\theta}$$
$$= \frac{0.154\,nm \times 1}{2\,Sin12°40'}$$
$$= 0.351\,nm$$

17. Vol: of unit cell = $(0.346\,nm)^3 = (0.346\,nm \times 10^{-7}\,cm)^3$
$= 4.142 \times 10^{-23}\,cm^3/\text{unit cell}$

$$(?)\,atoms/\text{unit cell} = \frac{6.023 \times 10^{23}\,atoms}{1mol} \times \frac{1\,mol}{7\,g} \times \frac{0.534\,g}{1\,cm^3}$$
$$= 1.9\,atoms \approx 2\,atoms/unitcell$$

$\therefore$ Li is body-centered cubic system.

18. **Coordination number**

Mg = H.C.P ------------- 12

Cu = F.C.C -------------- 12

Na = B.C.C -------------- 8

Chapter 7

9.
$$\mu = 1.84\ \text{D} \times \frac{3.34 \times 10^{-30}\ \text{C.m}}{1\text{D}} = 6.1456 \times 10^{-30}\ \text{C.m}$$
$$d = 0.095\ \text{nm} \times 10^{-9}\ \text{m}$$
$$\delta = \frac{\mu}{d} = \frac{6.1456 \times 10^{-30}\ \text{C.m}}{0.095\ \text{nm} \times 10^{-9}\ \text{m}} = 6.469 \times 10^{-20}\ \text{C}$$
$$\%\ \text{ionic character} = \frac{6.469 \times 10^{-20}\ \text{C}}{1.6 \times 10^{-19}\ \text{C}} \times 100 = 40.43\%$$

Problem no. 10 and 11 are the same as no.9.

12. $C_{(s)} + 2H_{2\,(g)} \rightarrow CH_{4\,(g)}$ $\Delta H_{rxm} = -792$ kJ

$$\Delta H_{rxn} = \sum \Delta H_{(reactants)} - \sum \Delta H_{(products)}$$

$$-792\ \text{kJ} = 2\Delta\Delta_{H_2} - \Delta H_{CH_4}$$
$$-792\ \text{kJ} = 2\Delta\Delta_{(H\text{-}H)} - 4\Delta\Delta_{(C\text{-}H)}$$
$$-792\ \text{kJ} = (2 \times 436) - 4\Delta\Delta_{(C\text{-}H)}$$
$$4\Delta\Delta_{(C\text{-}H)} = 1664$$
$$4\Delta\Delta_{(C\text{-}H)} = 416\ \text{kJ mol}^{-1}$$

(C-H) bond energy is 416 kJ/mol

Problem no. 13 and 14 are the same as no.12.

Chapter 8

May be for self-study of hybridized configurations.

Chapter 9

1. $$(?)\,\text{mass}\ H_2SO_4 = \frac{\text{mass}\ \%\ H_2SO_4\ \text{x}\ \ \text{mass of solution}}{100}$$
$$= \frac{15\ \text{x}\ 25}{100} = 3.75\ \text{g}$$

2. $$(?)\,\text{mole}\ H_2SO_4 = 20\ \text{g x}\ \frac{1\ \text{mol}}{100\ \text{g}} = 0.2041\ \text{mol}$$
$$(?)\,\text{kg}\ H_2O = 80\ \ \text{x}\ 10^{-3}\ \text{kg}\ H_2O$$

$$\text{Molality} = \frac{\text{mole of solute}}{\text{kg of solvent}} = \frac{0.2041\ \text{mole}}{0.08\ \text{kg}} = 2.55\ \text{m}$$
$$(?)\,\text{g of}\ NH_3 = 14.8\ \text{mol}\ NH_3\ \text{x}\ \frac{17\ \text{g}}{1\ \text{L of}\ NH_3} = 251.6\ \text{g}$$

3. $$(?)\,\text{g of}\ NH_{3(aq)} = 1\ \text{L}\ NH_{3(aq)}\ \text{x}\ \frac{0.898\ \ \text{g}\ NH_{3(aq)}}{10^{-3}\ \ \text{L of}\ NH_{3(aq)}} = 898\ \text{g}\ NH_{3(aq)}$$
$$(?)\,\text{g of water} = (898 - 251.6)\ \text{g} = 646.4\ \text{g}\ H_2O$$
$$(?)\,\text{mol of water} = 646.4\ \text{g}\ H_2O\ \text{x}\ \frac{1\ \text{mol}}{18\ \text{g}\ H_2O} = 35.91\ \text{mol}\ H_2O$$
$$X_{NH_3} = \frac{14.8}{14.8 + 35.91} = 0.2918$$

4. $$(?)\,\text{M}\ H_2SO_4 = \frac{1\ \text{mol}\ H_2SO_4}{98\ \text{g}\ H_2SO_4}\ \text{x}\ \frac{10\ \text{g}\ H_2SO_4}{100\ \text{g}\ H_2SO_{4(aq)}}\ \text{x}\ \frac{1.079\ \text{g}\ \ H_2SO_{4(aq)}}{10^{-3}\ \text{L}\ H_2SO_{4(aq)}}$$
$$= 1.092\ \text{mol/L} = 1.092\ \text{M}$$

5. <u>1.12 M, $CH_3OH_{(aq)}$ 1 kg (Before dilution)</u>

$$(?)\,\text{g}\ CH_3OH = 1.12\ \text{mol x}\ \frac{32\ \text{g}}{1\ \text{mol}} = 35.84\ \text{g}\ CH_3OH$$
$$(?)\,\text{g}\ CH_3OH_{(aq)} = 35.84 + 1000\ \text{g}\ H_2O = 1035.84\ \text{g}$$
$$(?)\,\text{g}\ H_2O\ \text{in 1 kg of given solution} = 1000\ \text{g}\ CH_3OH_{(aq)}\ \text{x}\ \frac{1000\ \text{g}\ H_2O}{1035.84\ \text{g}\ CH_3OH_{(aq)}}$$
$$= 965.4\ \text{g}\ H_2O$$

$$(?)\,g\,CH_3OH = 000\ \ g\,CH_3OH_{(aq)} \times \frac{3\ .84\ \ g\,CH_3OH}{03\ .84\ \ g\,CH_3OH_{(aq)}} = 34.6\,g\,CH_3OH$$

$$(?)\,g\,H_2O \text{ after diluton} = 34.6\,g\,CH_3OH_{(aq)} \times \frac{mol}{32\,g} \times \frac{000\ \ g\,H_2O}{mol}$$

$$= 08\ .2\ \ \ g\,H_2O$$

$$(?)\,g\,H_2O \text{ added} = 08\ .2\ \ -96\ .4\ = \ \ .8\ \ \ g \text{ of } H_2O$$

6. $C_1 = 48.9\ mL\ O_2\ L^{-1}$ $\quad$ $C_2 = ?$

$P_1 = 1\ atm$ $\quad$ $P_2 = 0.02095\ atm$

By Henry's law,

$$\frac{C_1}{P_1} = \frac{C_2}{P_2}$$

$$C_2 = \frac{48.9 \times 0.20}{} = 0.24\ \ \ mL\,O_2L_{-1}$$

7. (a)

$$(?)\,mol\,C_2H_5OH = 13.2\,g\ \times \frac{1\,mol\,C_2H_5OH}{46\,g\,C_2H_5OH} = 0.2869\,mol$$

$$(?)\ mol\,H_2O\ = 86.8\,g \times \frac{1\,mol\,H_2O}{18\,g\,H_2O} = 4.82\,mol$$

$$X_{C_2H_5OH} = \frac{n_{C_2H_5OH}}{n_{C_2H_5OH} + n_{H_2O}} = 0.0562$$

(b) $(?)\ mol\,H_2O\ = 1000\,g\,H_2O \times \frac{1\,mol}{18\,g} = 55.56\,mol\,H_2O$

$$X_{CO(NH_2)_2} = \frac{0.512}{0.512\ + 55.56} = 9.13 \times 10^{-3}$$

8. $(?)\ mol\,CO(NH_2)_2\ = 26.9\,g\ \times \frac{1\,mol}{60\,g} = 0.4483\,mol$

$$(?)\,mol\,H_2O = 712\,g \times \frac{1\,mol}{18\,g} = 39.55\,mol$$

$$X_{H_2O} = \frac{n_{H_2O}}{n_{CO(NH_2)_2}\ +\ n_{H_2O}} = 0.988$$

9. $\Delta T_b = K_b\, m$

$= 0.512^oC\ m^{-1} \times 0.205\ m = 0.10496^oC$

$\Delta T_b = T_{solution} - T_{solvent}$

$= 0.10496^oC - 100^oC = 100.10496^oC$

The solution is formed to be boiled at 100.025°C that is less than calculated value. ∴ Actual atmospheric pressure is less than 760 mm Hg.

10. $\text{Mass \%} = \dfrac{\text{mass of solute}}{\text{massofsolution}} \times 100$

$(?)\ \text{mol of } C_2H_{12}O_6 = 30\ g \times \dfrac{1\ mol}{180\ g} = 0.167\ mol$

$m = \dfrac{0.167\ mol}{70 \times 10^{-3} g} = 2.386\ m$

$\Delta T_b = K_b\, m$

$= 0.512\ ^oC\ m^{-1} \times 2.386\ m = 1.22\ ^oC$

$\Delta T_b = T_{solution} - T_{solvent}$

$= 1.22\ ^oC - 100^oC = 101.22\ ^oC$

11. Solutions for the problem are

$\Delta T_f = 0.56\ ^oC$, $m = 0.1093m$, and molecular wt: = 220 amu respectively.

13. $\pi = \dfrac{3.56}{760} atm = 4.68 \times 10^{-3} atm$

$T = 25^oC + 273 = 298\ K$

$\pi V = nRT$

$n = \dfrac{\pi V}{RT} = \dfrac{4.68 \times 10^{-3}\ atm \times 25 \times 10^{-3}\ L}{0.0821\ L\ atm\ mol^{-1}K^{-1} \times 298\ K}$

$= 4.786 \times 10^{-6} mol$

$\text{Molar mass of protein} = \dfrac{0.288\ g}{4.786 \times 10^{-6}\ mol} = 60175.5\ g/mol$

Chapter 10

1, (a) $H_2O + OCl^- \rightleftharpoons HOCl + OH^-$

acid — base — conjugate acid — conjugate base

(b) $H_2PO_4^- + NH_3 \rightleftharpoons NH_4^+ + HPO_4^{2-}$

acid — base — conjugate acid — conjugate base

2. $PV = nRT$

$$n = \frac{PV}{RT} = \frac{0.9829 \text{ atm x } 535 \text{ x } 10^{-3}\text{ L}}{0.08206 \text{ L atm mol}^{-1}\text{ K}^{-1} \text{ x } 299.5 \text{ K}}$$

$$= 0.0214 \text{ mol } N_2$$

$$M = \frac{0.0214 \text{ mol}}{625\text{x}10^{-3}\text{ L}} = 0.0342 \text{ mol L}^{-1}$$

$HCl \rightarrow H^+ + Cl^-$

0.0342 mol L^{-1} — 0.0342 mol L^{-1}

$[H^+] = 0.0342$ mol L^-

$-\log [H^+] = -\log (0.0342)$

pH = 1.47

3. $$(?)[KOH] = \frac{1 \text{ mol KOH}}{56\text{gKOH}} \text{ x } \frac{3 \text{ g KOH}}{100 \text{ g KOH}_{(aq)}} \text{ x } \frac{1.0242 \text{ g KOH}_{(aq)}}{0.001 \text{ L KOH}_{(aq)}} = 0.5486 \text{ mol L}^{-1}$$

$KOH \rightarrow K^+ + OH^-$

0.5486 mol L^{-1} — 0.5486 mol L^{-1}

$[OH^-] = 0.5486$ mol L^-

$-\log [OH^-] = -\log (0.5486)$

pOH = 0.2607

pH = 14 – pOH

= 14 – 0.2607

= 13.7393

4. $HCOONa \rightarrow HCOO^- + Na^+$

0.01 M 0.01 M 0.01 M

	$HCOOH$	$\rightleftharpoons$	$HCOO^-$	+	H^+
Initial	0.1 M				
Change	x		x		x
Equili. Conc.	(0.1 - x)		(0.01 + x)		x

$$K_a = \frac{[HCOO^-][H^+]}{[HCOOH]}$$

$$1.8 \times 10^{-5} = \frac{(0.01 + x)(x)}{(0.1 - x)}$$

Assuming that x is very small, compared to 0.1.

$$\frac{0.01\,x}{0.1} = 1.8 \times 10^{-5}$$

$$x = [H^+] = 1.8 \times 10^{-4}$$

$$pH = 3.74$$

(b) To be solved likely to the way as no. (a).

pH = 5.1

$[H^+] = 7.94 \times 10^{-6}$ M

5. $CH_3COONa \rightarrow CH_3COO^- + Na^+$

a a a

	CH_3COOH	$\rightleftharpoons$	CH_3COO^-	+	H^+
Initial	0.25 M				
Change	x		x		x
Equili. Conc.	(0.25 - x)		(a + x)		x

$$K_a = \frac{[HCOO^-][H^+]}{[HCOOH]}$$

$$1.8 \times 10^{-5} = \frac{(a + x)(x)}{(0.25 - x)}$$

Assuming that x is very small, compared to 0.25.

$a = 0.5476\ M = [CH_3COO^-] = [CH_3COONa]$

$$(?)\ g\ CH_3COONa = 0.3\ L \times \frac{0.5476\ mol}{1\ L} \times \frac{82\ g}{1\ mol}$$

$$= 13.47\ g\ CH_3COONa$$

6. pH = 10.08

$\therefore pOH = 3.92$

$\therefore [OH^-] = 10^{-pOH}$

$= 10^{-3.92}$

$= 1.2 \times 10^{-4}\ mol\ L^{-1}$

$$[cocaine] = [C_{17}H_{21}O_4N] = \frac{0.17\ g}{0.1\ L} \times \frac{0.1\ mol}{303g}$$

$$= 5.61 \times 10^{-3}\ M$$

	$C_{17}H_{21}O_4N$ + H_2 $\rightleftharpoons$	$C_{17}H_{21}O_4NH^+$ +	OH^-
Initial	$5.61 \times 10^{-3}M$		
Change	x	x	x
Equili. Conc.	$(5.61 \times 10^{-3} - x)$	x	x

$$K_b = \frac{[C_{17}H_{21}O_4NH^+][OH^-]}{[C_{17}H_{21}O_4N][H_2O]}$$

$$= \frac{x^2}{(5.61 \times 10^{-3} - x)}$$

Assuming that x is very small, compared to 0.1.

$$K_b = \frac{(1.2 \times 10^{-4})^2}{(5.61 \times 10^{-3})} = 2.57 \times 10^{-6}$$

7. $M(OH)_3 \rightleftharpoons M^{3+} + 3OH^-$

1×10^{-5} $\quad 1 \times 10^{-5}$ $\quad 1 \times 10^{-5}$

$K_{sp} = [M^{3+}][3OH^-]$

$= (10^{-5} \times 3 \times 10^{-5})^3$

$= 2.7 \times 10^{-19}$

8. $Ag_2CO_3 \rightleftharpoons 2Ag^+ + CO_3^{2-}$

1.16×10^{-4} $\quad 2 \times 1.16 \times 10^{-4}$ $\quad 1.16 \times 10^{-4}$

$K_{sp} = [Ag^+]^2 [CO_3^{2-}] = 6.24 \times 10^{-12}$

9. To be solved in such a way as no.7, and 8.

Chapter 11

1.

	S_2	$\rightleftharpoons$ $2S$
Initial	0.001 mol	
Change	$\frac{1}{2} \times 10^{-11}$	1×10^{-11}
Equili.	$0.001 - (\frac{1}{2} \times 10^{-11})$	1×10^{-11}
	9.99×10^{4} mol	10^{-11} mol
Equili. Conc.	$\frac{9.99 \times 10^{4}}{0.5}$	$\frac{10^{-11}}{0.5}$
	1.99×10^{-3} M	2×10^{-11} M

$$K_C = \frac{[S]^2}{[S_2]} = \frac{(2x10^{-11})^2}{1.99x10^{-3}} = 2x10^{-19}$$

$K_P = K_C (RT)^{\Delta n}$ $\qquad \Delta n = (2 - 1) = 1$

$= 2 \times 10^{-19} \times (0.0821 \times 1000)^1$

$= 1.65 \times 10^{-17}$

2. In being so, like the same as no.1.

3. (a) and (b) are true.

4. May be to calculate like as no.1 and also as no.2.

5. See pg: 125 (**Relation bet: K_P and K_C**)

SOLUTIONS

FOR

E.Ph 01011

ENGINEERING PHYSICS

*   Must Know

**   Should Know

***   Could Know

NOTE: Respective examples in each chapter must be taken as MUST KNOW.

CHAPTER I

Question :

*1.1 What do you understand by the term " dimension of a physical quantity ?

Solution:

Dimension of a physical quantity is the power which is needed to put on base quantities.

*1.2 Write down the dimensional notations for the following quantities :

(a) momentum (b) the constant of gravitation G

(c) potential energy (d) torque or moment of force .

Solution:

(a) momentum = mass x velocity

$$= \text{mass} \times \frac{\text{length}}{\text{time}} = [MLT^{-1}]$$

(b) force $= G \dfrac{\text{mass} \times \text{mass}}{(\text{distance})^2}$ (Universal gravitational law)

$$\therefore \quad G = \frac{\text{force} \times (\text{distance})^2}{(\text{mass})^2}$$

Since force $= \text{mass} \times \dfrac{\text{length}}{(\text{time})^2}$

$$G = \frac{\text{mass} \times \text{length}}{(\text{time})^2} \times \frac{(\text{distance})^2}{(\text{mass})^2}$$

$$= [M^{-1}L^3T^{-2}]$$

(c) potential energy = mass x acceleration due to gravity x height

$$= [MLT^{-2}L]$$

$$= [ML^2T^{-2}]$$

(d) torque or moment of force = force × perpendicular distance

$$= [MLT^{-2}][L]$$

$$= [ML^2T^{-2}]$$

*
1.3 State the principle of dimensional homogeneity.

Solution :

A physically correct equation must have the same dimensions (or units) on both the right-hand side (RHS) and the left-hand side (LHS) of the equation.

*
1.4 What are the fundamental quantities? How many are there, and what are they?

Solution :

Fundamental quantities are quantities which are used to describe other physical quantities.

There are seven fundamental quantities and they are :

(i) Length
(ii) Mass
(iii) Time
(iv) Electric current
(v) Temperature
(vi) Amount of substance
(vii) Luminous intensity

*
1.5 What are derived quantities?

Solution:

Derived quantities are physical quantities, which can be described in terms of fundamental quantities.

*
1.6 In the statement "The mass of a block wood is 2 kilogram", what does kilogram stand for and what does kilogram stand for and what does 2 stand for.

Solution :

Kilogram stand for unit and 2 stand for numerical magnitude.

1.7. * Is mass a fundamental physical quantity (or) derived quantity ? Give reason.

Solution:

Yes, mass is a fundamental physical quantity. Other physical quantities such as momentum, force and kinetic energy can be described in terms of mass as shown below.

momentum = mass x velocity

force = mass x acceleration

kinetic energy = $\frac{1}{2}$ x mass x $(\text{velocity})^2$

1.8 * Is force a fundamental quantity ? Give reason.

Solution :

No, force is not a fundamental quantity. It is a derived quantity. Force can be described by fundamental quantities, mass, length and time as shown below.

$$\text{force} = \text{mass} \times \text{acceleration}$$

$$= \text{mass} \times \frac{\text{length}}{(\text{time})^2}$$