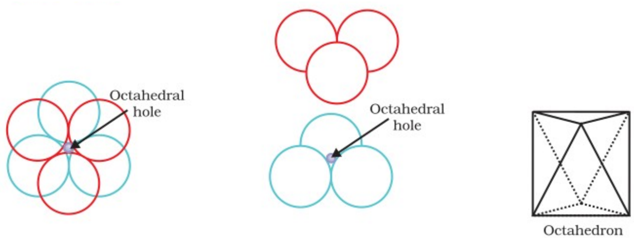
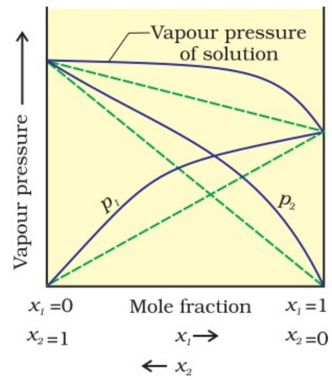
HSE II FIRST TERM 2019–20 CHEMISTRY (SFE 25) ANSWERS

Maximum: 60 score

Q. No	Answer/ Scoring indicators
	Answer all questions from 1 - 7. Each carries 1 score (7 x 1 = 7)
1.	Tetragonal.
2.	Isotropic.
3.	Osmotic pressure.
4.	Cl_2
5.	Fuel cell.
6.	Zero.
7.	Al^{3+}
	Answer any 10 questions from 8 to 20. Each carries 2 scores. (10 x 2 = 20)
8.	(a) (a) ↑ ↑ ↑ ↑ ↑ ↑ (b) A few substances like iron, cobalt, nickel, gadolinium and CrO_2 are attracted very strongly by a magnetic field. Such substances are called ferromagnetic substances. TIn solid state, the metal ions of ferromagnetic substances are grouped together into small regions called domains. Each domain acts as a tiny magnet. When the substance is placed in a magnetic field all the domains get oriented in the direction of the magnetic field and a strong magnetic effect is produced.
9.	(a) Voids surrounded by six spheres in a three dimensional close packing are called octahedral voids. (b) Let the number of close packed spheres in fcc lattice be N, then the number of octahedral voids generated = N 
10.	Since the lattice is ccp, the number of silver atoms per unit cell = z = 4 Molar mass of silver = 107.9 g mol = 107.9×10^{-3} kg mol^{-1} Edge length of unit cell = a = 408.6 pm = 408.6×10^{-12} m Density, d = $\frac{z.M}{N_A a^3}$ = $(4 \times 107.9 \times 10^{-3}$ kg $mol^{-1}) / (6.022 \times 10^{23}$ $mol^{-1} \times (408.6\times10^{-12}$ $m)^3)$ = 10.5×10^{3} kg m^{-3} = 10.5 g cm^{-3}
11.	(a) Henry's law states that 'at a constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas.' OR 'mole fraction of gas in the solution is proportional to the partial pressure of the gas over the solution. OR "the partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of the gas (x) in the solution" and is expressed as: $p = K_H x$ Here K_H is the Henry's law constant. (b) Higher the value of K_H at a given pressure, the lower is the solubility of the gas in the liquid. K_H value for O_2 increase with increase of temperature indicating that the solubility of O_2 increases with decrease of temperature. It is due to this reason that aquatic species are more comfortable in cold waters rather than in warm waters.

12. (a) If the vapour pressure of a non-ideal solution is higher than that predicted by Raoult's law, the solution exhibits positive deviation. The plots of vapour pressure as a function of mole fractions for such solutions are shown in figure.
(b) In pure ethanol, molecules are hydrogen bonded. On adding acetone, its molecules get in between the ethanol molecules and break some of the hydrogen bonds between them. Due to weakening of interactions, the solution shows positive deviation from Raoult's law



13. (a) van't Hoff introduced a factor i, known as the van't Hoff factor, to account for the extent of dissociation or association. This factor i is defined as: i = $\frac{Normal\ molar\ mass}{Abnormal\ molar\ mass}$ OR

i = $\frac{Observed\ colligative\ property}{Calculated\ colligative\ property}$ OR

i = $\frac{Total\ number\ of\ moles\ of\ particles\ after\ association/dissociation}{Number\ of\ moles\ of\ particles\ before\ association/dissociation}$

(b) In case of dissociation, value of i is greater than unity. (i > 1) For example, the value of i for aqueous KCl solution is close to 2.

14. (a) Mg / Mg^{2+} // Ag^{+} / Ag

(b) $E_{(cell)} = E^{\ominus}_{(cell)} - \frac{RT}{2F}\ln\frac{[Mg^{2+}]}{[Ag^{+}]^2}$

15. (a) The charge on one mole of electrons is called one Faraday of electricity.
1F = 96487 C mol $^{-1}$ ≈ 96500 C mol $^{-1}$.
(b) One mole of Al^{3+} require 3 mol of electrons. ie, 3F

16. (a) Molar conductance (Λ_m) of a solution at a given concentration is the conductance of a solution containing one mole of electrolyte kept between two electrodes with area of cross section A and distance of unit length.
(b) Molar conductance increases with decrease in concentration (increase in dilution).

17. (a) In a chemical reaction between two substances when one reactant is present in large excess, its concentration does not get altered much during the course of the reaction. So its concentration can be taken as constant and the reaction behaves as first order reaction. Such reactions are called pseudo first order reactions. OR. Reactions which appear to be of higher order but actually follow first order kinetics are called pseudo first order reactions.
(b) Rate = k [$C_{12}H_{22}O_{11}$]

18.

Order of a Reaction	Molecularity of a Reaction
1. It is the sum of powers of the concentration of the reactants in the rate law expression.. 2. It is an experimental quantity. 3. It can be zero and even a fraction. 4. It is applicable to elementary as well as complex reactions.	1. It is the number of reacting species which must collide simultaneously in order to bring about a chemical reaction. 2. It is a theoretical concept. 3. It cannot be zero or a non integer. 4. It is applicable only for elementary reactions.

19. (a) Colloidal sols directly formed by mixing substances like gum, gelatine, starch, rubber, etc., with a suitable liquid (the dispersion medium) are called lyophilic (solvent attracting) colloids.

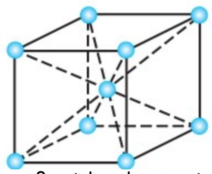
(b) If the dispersion medium of a Lyophilic colloid is separated from the dispersed phase (say by evaporation), the sol can be reconstituted by simply remixing with the dispersion medium. That is why these colloids are also called reversible colloids.

20. When light is passed through a colloidal solution in dark room, scattering of light illuminates the path of beam in the colloidal dispersion. This is called Tyndall effect. The bright cone of the of the light is called Tyndall cone. Tyndall effect is used to distinguish between a colloidal and true solution. Tyndall effect is observed only when the following two conditions are satisfied. (i) The diameter of the dispersed particles is not much smaller than the wavelength of the light used; and (ii) The refractive indices of the dispersed phase and the dispersion medium differ greatly in magnitude.

Answer any 7 questions from 21 to 29. Each carries 3 scores. (7 x 3 = 21)

21. (a) The regular three dimensional arrangement of constituent particles in a crystal as points in space is called a crystal lattice. Unit cell is the smallest portion of a crystal lattice which, when repeated in different directions, generates the entire lattice.

(b) (i) Body- Centred Cubic Unit Cell (bcc)



Particles at 8 corners & at body centre.

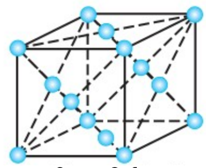
A particle at corner is shared between 8 unit cells and at body centre totally belongs to the unit cell.

(i) 8 corners × $\frac{1}{8}$ per corner atom $= 8 \times \frac{1}{8}$ = 1 atom

(ii) 1 body centre atom = 1 × 1 = 1 atom

∴ Total number of atoms per unit cell = 2 atoms

(ii) Face- Centred Cubic Unit Cell (fcc)



Particles at 8 corners & at 6 face centres.

A particle at corner is shared between 8 unit cells & at face centre is shared between 2 unit cells

(i) 8 corners atoms × $\frac{1}{8}$ atom per unit cell $= 8 \times \frac{1}{8}$ = 1 atom

(ii) 6 face-centred atoms × $\frac{1}{2}$ atom per unit cell = 6 × $\frac{1}{2}$ = 3 atoms

∴ Total number of atoms per unit cell = 4 atoms

22. (a) In Frenkel (dislocation) defect, some cations are dislocated from its normal site to an interstitial site. It creates a vacancy defect at its original site and an interstitial defect at its new location.

(b)

Schottky defect	Frenkel (dislocation) defect
It is formed by missing equal number of cations and anions.	It is formed by the dislocation of some cations from its normal site to an interstitial site.
It is a vacancy defect.	It creates a vacancy defect at its original site and an interstitial defect at its new location.
It decreases density of the substance.	It does not change the density of the solid.
It is shown by ionic substances in which the cation and anion are of almost similar sizes.	It is shown by ionic substances in which cations are smaller than anions.
Eg: NaCl, KCl, CsCl and AgBr.	Eg: ZnS, AgCl, and AgI

(c) AgBr

23. (a) Raoult's law states that for a solution of volatile liquids, the partial vapour pressure of each component in the solution is directly proportional to its mole fraction.

(b) For component 1, $p_1 \propto x_1$ or $p_1 = p_1^0 x_1$

where p_1^0 is the vapour pressure of pure component 1 at the same temperature.

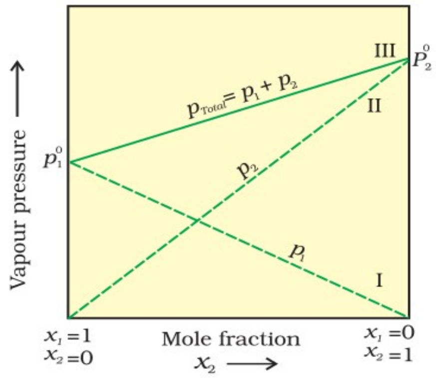
Similarly, for component 2 $p_2 \propto x_2$ or $p_2 = p_2^0 x_2$

where p_2^0 is the vapour pressure of pure component 2 at the same temperature.

According to Dalton's law of partial pressures, the total pressure (p_{total}) in the container will be the sum of the partial pressures of the components of the solution and is given as: $p_{total} = p_1 + p_2$

Substituting the values of p_1 and p_2, we get $p_{total} = x_1 p_1^0 + x_2 p_2^0$

(c) Graphical representation of Raoult's law



24. (a) azeotropes are binary mixtures having the same composition in liquid and vapour phase and boil at a constant temperature.

(b) There are two types of azeotropes:

Minimum boiling azeotrope	Maximum boiling azeotrope
The solutions which show a large positive deviation from Raoult's law form minimum boiling azeotrope at a specific composition.	The solutions which show large negative deviation from Raoult's law form maximum boiling azeotrope at a specific composition.
Eg: ethanol-water mixture containing approximately 95% by volume of ethanol.	Eg: A mixture of 68% nitric acid and 32% water by mass, with a boiling point of 393.5 K.

25. (a) Kohlrausch law of independent migration of ions states that limiting molar conductivity of an electrolyte can be represented as the sum of the individual contributions of the anion and cation of the electrolyte.

(b) $\Lambda m^o_{(HAc)} = \lambda^o_{H+} + \lambda^o_{Ac} = \lambda^o_{H+} + \lambda^o_{Cl-} + \lambda^o_{Ac} + \lambda^o_{Na+} - \lambda^o_{Cl-} - \lambda^o_{Na+}$

$= \Lambda_m^o{}_{(HCl)} + \Lambda_m^o{}_{(NaAc)} - \Lambda_m^o{}_{(NaCl)}$

$= (425.9 + 91.0 - 126.4)$ S cm 2 mol^{-1}

$= 390.5$ S cm^2 mol^{-1}.

26. Corrosion is an electrochemical phenomenon. At a particular spot of an object made of iron, oxidation takes place and that spot behaves as anode. Electrons released at anodic spot move through the metal and go to another spot on the metal and reduce oxygen in presence of H^+.This spot behaves as cathode.

The reaction at Anode is $2 Fe_{(s)} \rightarrow 2 Fe^{2+} + 4 e^-$

The ferrous ions are further oxidised by atmospheric oxygen to ferric ions which come out as rust in the form of hydrated ferric oxide ($Fe_2O_3 . x H_2O$)

27. (a) The temperature dependence of the rate of a chemical reaction can be explained by Arrhenius equation $k = A e^{-Ea/RT}$ where A is the Arrhenius factor or the frequency factor (pre-exponential factor). R is gas constant and E_a is activation energy.

(b) $T_1 = 600K$ $k_1 = 1.60 \times 10^{-5}$ $T_2 = 700K$ $Ea = 809000\ Jmol^{-1}$

$$\log k_2 - \log k_1 = \frac{E_a}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\log k_2 = \log k_1 + \frac{E_a}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\log k_2 = \log(1.60 \times 10^{-5}) + \frac{809000}{2.303 \times 8.314}\left[\frac{1}{600} - \frac{1}{700}\right]$$

$\log k_2 = -4.796 + 10.0559 = 5.2599$

$k_2 =$ anti log (5.2599)

28. (a) Freundlich adsorption isotherm can be expressed by the following equation: $\frac{x}{m} = k.P^{1/n}$ (n > 1)

where x is mass of the gas adsorbed on mass m of the adsorbent at pressure P, k and n are constants.

(b)

Physisorption	Chemisorption
1. It arises because of van der Waals' forces.	1. It is caused by chemical bond formation.
2. It is not specific in nature.	2. It is highly specific in nature.
3. It is reversible in nature.	3. It is irreversible.
4. Enthalpy of adsorption is low	4. Enthalpy of adsorption is high
5. It results into multimolecular layers.	5. It results into unimolecular layer.

29. (a) The enzymes are biochemical catalysts.

(b) The invertase enzyme converts cane sugar into glucose and fructose.

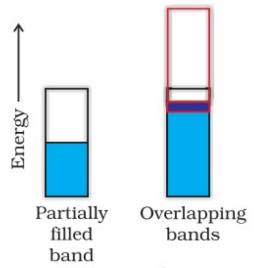
The zymase enzyme converts glucose into ethyl alcohol and carbon dioxide.

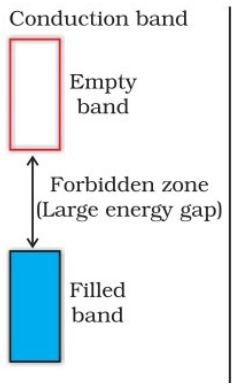
(c) Most highly efficient, Highly specific nature, Highly active under optimum temperature and pH

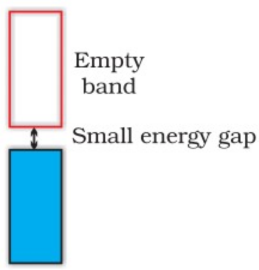
Answer any 3 questions from 30 to 33. Each carries 4 scores. (3 x 4 = 12)

30. Solids can be classified into three types on the basis of their conductivities. In solids, The atomic orbitals form molecular orbitals which are so close in energy to each other as to form a band. The highest energy band which is occupied by electrons is called valence band and the lowest energy band which is unoccupied by electrons is called conduction band.

Conductors	Insulators	Semiconductors
The valence band is partially filled or it overlaps with conduction band. Then electrons can flow easily and can show conductivity.	The gap between valence band and the conduction band is large. Electrons cannot jump to it and it has very small conductivity.	The gap between the valence band and conduction band is small. Some electrons may jump to conduction band and show some conductivity.







31. (a) Properties of dilute solutions which depend on the number of solute particles irrespective of their nature relative to the total number of particles present in the solution are called colligative properties.

(b) (1) relative lowering of vapour pressure of the solvent (2) depression of freezing point of the solvent (3) elevation of boiling point of the solvent and (4) osmotic pressure of the solution.

(c)

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

$$M_2 = \frac{5.12\ \text{K kg mol}^{-1} \times 1.00\ \text{g} \times 1000\ \text{g kg}^{-1}}{0.40 \times 50\ \text{g}} = 256\ \text{g mol}^{-1}$$

Thus, molar mass of the solute = 256 g mol^{-1}

32. (a) Standard hydrogen electrode.

(b) The standard hydrogen electrode consists of a platinum electrode coated with platinum black. The electrode is dipped in an acidic solution and pure hydrogen gas is bubbled through it. The pressure of hydrogen gas is one bar and the concentration of hydrogen ion in the solution is one molar

(c) The standard hydrogen electrode is coupled with Zn electrode to form the cell:

$Pt_{(s)}$ / $H_{2\,(g,\,1\,bar)}$ /$H^{+}_{(aq,\,1\,M)}$// $Zn^{2+}_{(aq,\,1M)}$ / Zn The measured emf of the cell is -0.76 V

$E_{cell} = E_R - E_L$ Since E_L is zero, -0.76 V corresponds to the standard electrode potential of Zn electrode.

33. (a) First order reaction.

(b) All natural and artificial radioactive decay of unstable nuclei take place by first order kinetics.

(c)

$$t_{1/2} = \frac{0.693}{k}$$

(d)