

- N.B. :** (1) All questions are **compulsory**.  
 (2) **Figures to the right** indicate **full marks**.  
 (3) Use of logarithm tables/non-programmable calculator is allowed.

**Physical Constants :**

$$N = 6.022 \times 10^{23}$$

$$F = 96,500 \text{ C}$$

$$R = 8.314 \text{ J / K}^{-1} \text{ mol}^{-1}$$

$$h = 6.626 \times 10^{-34} \text{ J.s}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$k = 1.38 \times 10^{-23} \text{ JK}^{-1}$$

$$\pi = 3.142$$

$$1 \text{ a.m.u.} = 1.66 \times 10^{-27} \text{ kg}$$

$$= 931 \text{ MeV.}$$

$$2.303 RT / F = 0.05916 \text{ at } 298 \text{ K}$$

$$Na = 23$$

$$Cl = 35.5$$

$$m_e = 9.0109 \times 10^{-31} \text{ kg}$$

1. Attempt any **three** of the following :-

- (A) Explain the concept of 'Activated complex'. 5  
 (B) Differentiate between thermoplastic and thermosetting polymers. 5  
 (C) Explain the effect of environment on the proton resonance in a magnetic field. 5  
 (D) Give reason :  
     (i) Tetramethyl silane is used as internal standard in NMR spectroscopy. 2  
     (ii) Three peaks are observed in NMR spectrum of ethanol. 3  
 (E) The reaction  $2XY \rightarrow X_2 + Y_2$  takes place at 560K at a concentration of 1 mol  $\text{dm}^{-3}$ . The total number of collisions taking place per second per cubic meter is  $5 \times 10^{20}$  and effective collisions are  $1.95 \times 10^{14}$  per second per cubic meter. Calculate the activation energy of the reaction. 5  
 (F) Calculate the number average molecular weight and weight average molecular weight for a polymer sample which has four different kinds of molar masses as  $1.5 \times 10^5$ ,  $5 \times 10^5$ ,  $2 \times 10^5$ ,  $3.5 \times 10^5$  present in the ratio 1:2 :3:4. 5

2. Attempt any **three** of the following :-

- (A) Explain how emf measurements can be used to determine changes in enthalpy, entropy and free energy of a cell reaction. 5  
 (B) Explain the use of quinhydrone electrode in the determination of  $p^H$ . 5  
 (C) Define the term overvoltage. How is it determined experimentally ? 5  
 (D) Why lithium is used to prepare high power battery ? Describe the components of a typical lithium-ion cell. 5  
 (E) Calculate the solubility product of AgCl and emf of the following cell at 298K 5  
     if solubility of AgCl is  $1.1 \times 10^{-5} \text{ mol dm}^{-3}$ .  
      $(-) \text{Ag/AgCl, KCl} \quad || \text{AgNO}_3 \quad | \text{Ag}^{(+)}$   
          $m = 0.1m \quad m = 0.1m$   
          $\gamma = 0.72 \quad \gamma = 0.82$

**[TURN OVER]**

- (F) At a current density of 1.0 milliamp/cm<sup>2</sup>, The overvoltage of hydrogen is 0.238V on platinum electrode. What will be the deposition potential of hydrogen on this electrode from a solution of pH 2.5 at 298 K ? 5
3. Attempt any **three** of the following :—
- (A) Explain the construction and working of Geiger-Muller counter. What are its limitations. 5
- (B) Describe the various components of a nuclear reactor. 5
- (C) Define artificial radioactivity. What are the different modes of decay of the artificial radioactive element. Explain. 5
- (D) Define nuclear fusion. Give the sequence of nuclear reactions in the carbon cycle. 5
- (E) <sup>235</sup>U has a half-life of  $7.2 \times 10^8$  years and its daughter element <sup>231</sup>Th has a half-life of 24.75 hour. What is the weight of <sup>231</sup>Th in equilibrium with one gram of <sup>235</sup>U 5
- (F) Define Q-value. 5
- For the following nuclear reaction  
 $^{33}\text{S} + {}^1_0\text{n} \rightarrow \text{P} + {}^1_1\text{H} + 0.53 \text{ MeV}$   
 What is the atomic mass of P ?  
 Given :  
 $^{33}\text{S} = 32.971460 \text{ amu}$   
 ${}^1_1\text{H} = 1.007825 \text{ amu}$   
 ${}^1_0\text{n} = 1.008665 \text{ amu}$
4. Attempt any **three** of the following :—
- (A) What is black body radiation. Which observations classical mechanics failed to explain ? How Planck was able to explain it. 5
- (B) Explain : 5
- (i) State function
- (ii) Linear operator
- (iii) Hamiltonian operator.
- (C) Draw well labelled diagram of : 5
- (i) Unit cell of NaCl
- (ii) Centre of symmetry in a simple cube
- (iii) Plans of symmetry (any two planes) in a simple cube.
- (D) Find the angle at which second order reflection maxima from (100) plane of NaCl is obtained. Wave length of X-rays used is  $1.54 \times 10^{-10} \text{ m}$ . Density of NaCl is  $2.17 \times 10^3 \text{ kg m}^{-3}$ . 5
- (E) Derive Bragg's equation. 5

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(F) (i) Determine which of the following is eigen function with eigen value when 5

operated by  $\frac{d^2}{dx^2}$ .

- (a)  $\sin x$  (b)  $5x^2$

(ii) obtain  $\widehat{A+B}$  if  $\widehat{A} = \frac{d}{dx}$ ,  $\widehat{B} = \int$  and  $f(x) = x^3$ .

5. (A) State whether the following statements are **true** or **false** :- 4

- (a) Natural polymers are monodispersed.  
 (b) The nucleus of  $^{12}_{24}\text{Mg}$  possesses half integral spin.  
 (c) Kinetics of fast reactions are studied by sedimentation velocity method.  
 (d) The solvent  $\text{CCl}_4$  can be used to obtain NMR spectra

**OR**

(A) Choose the correct answer :- 4

- (p) The nucleus of  $^{16}_8\text{O}$  has \_\_\_\_\_ spin.  
 (i) Zero (ii) half integral (iii) integral  
 (q) \_\_\_\_\_ is synthetic polymer.  
 (i) Cellulose (ii) nylon (iii) wool.  
 (r) The activated complex theory of reaction rates is based on \_\_\_\_\_.  
 (i) kinetic theory of gases (ii) Collision frequency  
 (iii) thermodynamic concepts.  
 (s) Number average molecular weight \_\_\_\_\_.  
 (i) is arithmetic mean (ii) is dependent on molecular size  
 (iii) is determined by sedimentation method.

5. (B) State whether the following statements are **true** or **false** :- 4

- (a) Glass electrode is ion selective electrode.  
 (b) When the temperature coefficient of a cell is positive, it becomes hot during its operation.  
 (c) The value of 'a' in Tafel's equation,  
 $\eta = a + b \log I$ , depends on cathode used.  
 (d) Hydrogen is called the fuel of future because it can be produced on large scale on earth and it is non-pollutant.

[TURN OVER

(B) Choose the correct answer :-

- (p) The fuel cell reaction is \_\_\_\_\_.  
 (i) reversible (ii) irreversible (iii) at equilibrium.
- (q) The value for  $E_G^\circ$  for all the glass electrodes is \_\_\_\_\_.  
 (i) same (ii) zero (iii) different
- (r) Overvoltage is affected by \_\_\_\_\_.  
 (i) current density (ii) pH (iii) both
- (s) Electroplating consists of depositing thin layer of \_\_\_\_\_ metal over \_\_\_\_\_ base metal.  
 (i) superior, inferior (ii) inferior, superior (iii) inferior, inert.

5. (C) State whether the following statements are **true** or **false** :-

- (a) The  $^{238}\text{U}$  can be converted into  $^{239}\text{Pu}$ .  
 (b) Nuclear fusion reaction involves chain reaction.  
 (c) In the nuclear transmutation reactions,  $\alpha$ -particles are better projectiles than neutrons.  
 (d) When the difference in decay constant of two radioelements in equilibrium is very large, then the equilibrium is called secular equilibrium.

**OR**

(C) Choose the correct answer :-

- (p) Threshold energy is given by \_\_\_\_\_.  
 (i)  $E_{\text{Th}} = Q \left( \frac{1+m_{\text{projectile}}}{m_{\text{Target}}} \right)$  (ii)  $E_{\text{Th}} = -Q \left( \frac{1+m_{\text{projectile}}}{m_{\text{Target}}} \right)$   
 (iii)  $E_{\text{Th}} = -Q \left( \frac{1+m_{\text{Target}}}{m_{\text{projectile}}} \right)$
- (q) Transmutation of  $^9_4\text{Be}$  into  $^{12}_6\text{C}$  is called (–, –) type of reaction.  
 (i)  $\alpha$ , n (ii)  $\alpha$ , a (iii)  $\alpha$ ,  $\gamma$
- (r) The activity of \_\_\_\_\_ disintegrations per second is called one Curie  
 (i)  $3.7 \times 10^7$  (ii)  $3.7 \times 10^{10}$  (iii)  $10^6$
- (s) The nuclear \_\_\_\_\_ reactions takes place in sun and other stars.  
 (i) fusion (ii) fission (iii) transmutation.

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5. (D) State whether the following statements are **true** or **false** :-

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- (a) The equation  $\hat{A}\Psi = a_i\Psi$  is called eigen value equation.
- (b) Photo electric effect proved that light has wave nature.
- (c) In NaCl crystal, one  $\text{Na}^+$  is surrounded by  $6\text{Cl}^-$  and one  $\text{Cl}^-$  is surrounded by  $6\text{Na}^+$ .

**OR**

(D) Choose the correct answer :-

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- (p) For a face centred cubic lattice, the length of edge of a cube is  $5.64 \times 10^{-10}$  m, then  $d_{100}$  is \_\_\_\_\_.  
(i) 282 pm (ii) 282 nm (iii) 56 nm.
- (q) Let two operators be  $\hat{A} = \frac{d}{dx}$ ,  $\hat{B} = \ln$ ,  $f(x) = \sin x$  these two operators are \_\_\_\_\_.  
(i) commutative (ii) non commutative (iii) Hamiltonian.
- (r) A simple cubic crystal has \_\_\_\_\_ planes of symmetry.  
(i) 6 (ii) 5 (iii) 9.