

## SECTION 1 (Maximum Marks: 18)

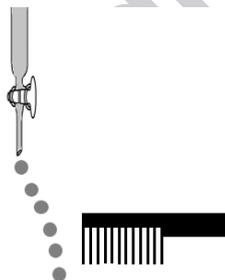
- This section contains **SIX (06)** questions.
- The answer to each question is a **SINGLE DIGIT INTEGER** ranging from **0 TO 9, BOTH INCLUSIVE**.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:  
*Full Marks* : +3 If ONLY the correct integer is entered;  
*Zero Marks* : 0 If the question is unanswered;  
*Negative Marks* : -1 In all other cases.

Q.1 The 1<sup>st</sup>, 2<sup>nd</sup>, and the 3<sup>rd</sup> ionization enthalpies,  $I_1$ ,  $I_2$ , and  $I_3$ , of four atoms with atomic numbers  $n$ ,  $n + 1$ ,  $n + 2$ , and  $n + 3$ , where  $n < 10$ , are tabulated below. What is the value of  $n$ ?

Atomic number	Ionization Enthalpy (kJ/mol)		
	$I_1$	$I_2$	$I_3$
$n$	1681	3374	6050
$n + 1$	2081	3952	6122
$n + 2$	496	4562	6910
$n + 3$	738	1451	7733

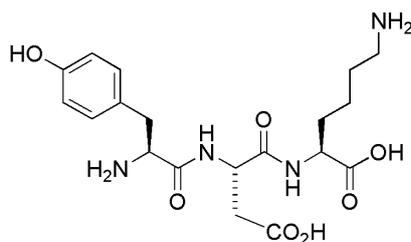
Q.2 Consider the following compounds in the liquid form:  
 $O_2$ , HF,  $H_2O$ ,  $NH_3$ ,  $H_2O_2$ ,  $CCl_4$ ,  $CHCl_3$ ,  $C_6H_6$ ,  $C_6H_5Cl$ .

When a charged comb is brought near their flowing stream, how many of them show deflection as per the following figure?



- Q.3 In the chemical reaction between stoichiometric quantities of  $KMnO_4$  and  $KI$  in weakly basic solution, what is the number of moles of  $I_2$  released for 4 moles of  $KMnO_4$  consumed?
- Q.4 An acidified solution of potassium chromate was layered with an equal volume of amyl alcohol. When it was shaken after the addition of 1 mL of 3%  $H_2O_2$ , a blue alcohol layer was obtained. The blue color is due to the formation of a chromium (VI) compound 'X'. What is the number of oxygen atoms bonded to chromium through only single bonds in a molecule of X?

Q.5 The structure of a peptide is given below.



If the absolute values of the net charge of the peptide at  $\text{pH} = 2$ ,  $\text{pH} = 6$ , and  $\text{pH} = 11$  are  $|z_1|$ ,  $|z_2|$ , and  $|z_3|$ , respectively, then what is  $|z_1| + |z_2| + |z_3|$ ?

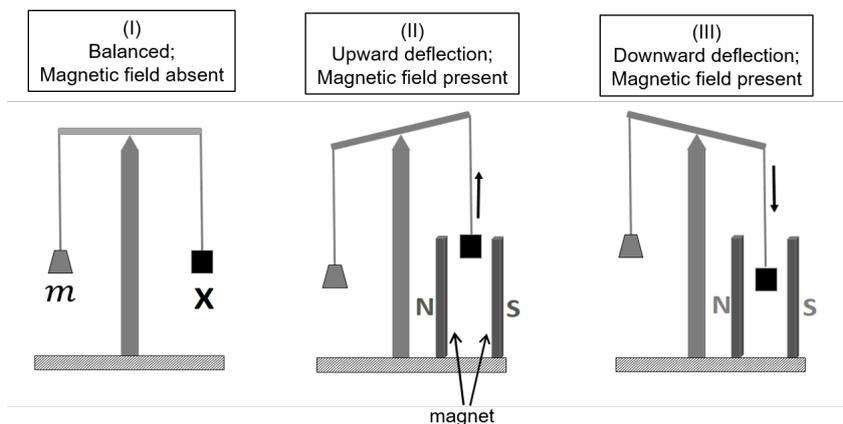
Q.6 An organic compound ( $\text{C}_8\text{H}_{10}\text{O}_2$ ) rotates plane-polarized light. It produces pink color with neutral  $\text{FeCl}_3$  solution. What is the total number of all the possible isomers for this compound?

**SECTION 2 (Maximum Marks: 24)**

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:
 

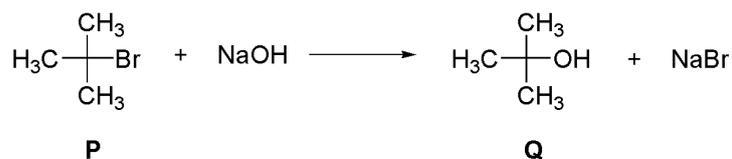
<i>Full Marks</i>	: +4	If only (all) the correct option(s) is(are) chosen;
<i>Partial Marks</i>	: +3	If all the four options are correct but ONLY three options are chosen;
<i>Partial Marks</i>	: +2	If three or more options are correct but ONLY two options are chosen, both of which are correct;
<i>Partial Marks</i>	: +1	If two or more options are correct but ONLY one option is chosen and it is a correct option;
<i>Zero Marks</i>	: 0	If none of the options is chosen (i.e. the question is unanswered);
<i>Negative Marks</i>	: -2	In all other cases.

- Q.7 In an experiment,  $m$  grams of a compound **X** (gas/liquid/solid) taken in a container is loaded in a balance as shown in figure **I** below. In the presence of a magnetic field, the pan with **X** is either deflected upwards (figure **II**), or deflected downwards (figure **III**), depending on the compound **X**. Identify the correct statement(s).

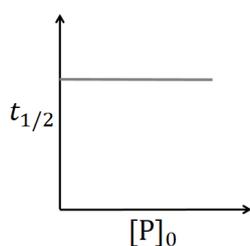


- (A) If **X** is  $\text{H}_2\text{O}(l)$ , deflection of the pan is upwards.  
 (B) If **X** is  $\text{K}_4[\text{Fe}(\text{CN})_6](s)$ , deflection of the pan is upwards.  
 (C) If **X** is  $\text{O}_2(g)$ , deflection of the pan is downwards.  
 (D) If **X** is  $\text{C}_6\text{H}_6(l)$ , deflection of the pan is downwards.

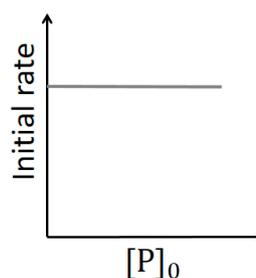
- Q.8 Which of the following plots is(are) correct for the given reaction?  
 ( $[P]_0$  is the initial concentration of **P**)



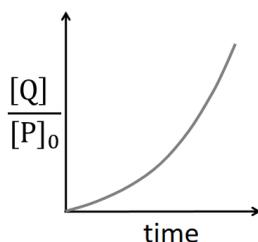
(A)



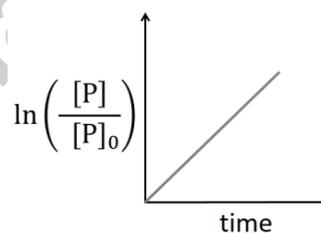
(B)



(C)



(D)



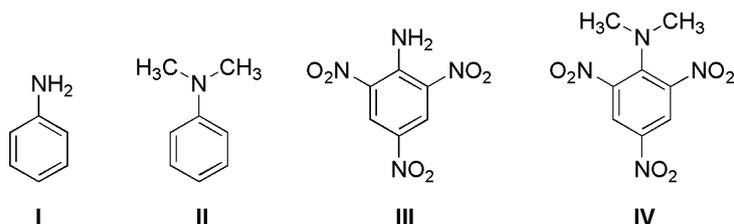
- Q.9 Which among the following statement(s) is(are) true for the extraction of aluminium from bauxite?

- (A) Hydrated  $\text{Al}_2\text{O}_3$  precipitates, when  $\text{CO}_2$  is bubbled through a solution of sodium aluminate.  
 (B) Addition of  $\text{Na}_3\text{AlF}_6$  lowers the melting point of alumina.  
 (C)  $\text{CO}_2$  is evolved at the anode during electrolysis.  
 (D) The cathode is a steel vessel with a lining of carbon.

- Q.10 Choose the correct statement(s) among the following.

- (A)  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$  is a reducing agent.  
 (B)  $\text{SnO}_2$  reacts with  $\text{KOH}$  to form  $\text{K}_2[\text{Sn}(\text{OH})_6]$ .  
 (C) A solution of  $\text{PbCl}_2$  in  $\text{HCl}$  contains  $\text{Pb}^{2+}$  and  $\text{Cl}^-$  ions.  
 (D) The reaction of  $\text{Pb}_3\text{O}_4$  with hot dilute nitric acid to give  $\text{PbO}_2$  is a redox reaction.

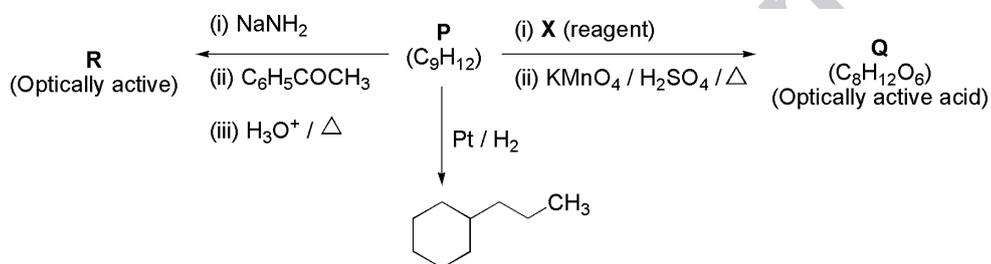
Q.11 Consider the following four compounds **I**, **II**, **III**, and **IV**.



Choose the correct statement(s).

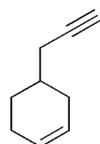
- (A) The order of basicity is **II** > **I** > **III** > **IV**.  
 (B) The magnitude of  $pK_b$  difference between **I** and **II** is more than that between **III** and **IV**.  
 (C) Resonance effect is more in **III** than in **IV**.  
 (D) Steric effect makes compound **IV** more basic than **III**.

Q.12 Consider the following transformations of a compound **P**.



Choose the correct option(s).

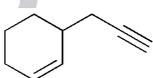
(A) **P** is



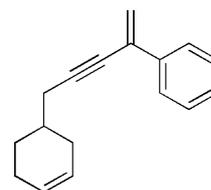
(B) **X** is

Pd-C/quinoline/H<sub>2</sub>

(C) **P** is



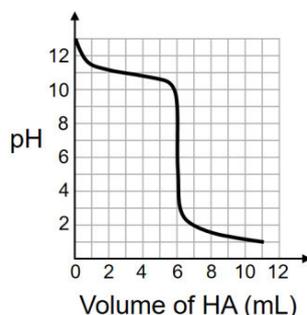
(D) **R** is



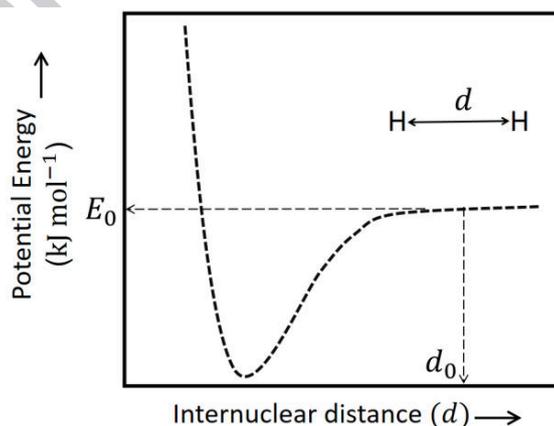
## SECTION 3 (Maximum Marks: 24)

- This section contains **SIX (06)** questions. The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated according to the following marking scheme:  
*Full Marks* : +4 If **ONLY** the correct numerical value is entered;  
*Zero Marks* : 0 In all other cases.

- Q.13 A solution of 0.1 M weak base (B) is titrated with 0.1 M of a strong acid (HA). The variation of pH of the solution with the volume of HA added is shown in the figure below. What is the  $pK_b$  of the base? The neutralization reaction is given by  $B + HA \rightarrow BH^+ + A^-$ .



- Q.14 Liquids **A** and **B** form ideal solution for all compositions of **A** and **B** at  $25^\circ\text{C}$ . Two such solutions with 0.25 and 0.50 mole fractions of **A** have the total vapor pressures of 0.3 and 0.4 bar, respectively. What is the vapor pressure of pure liquid **B** in bar?
- Q.15 The figure below is the plot of potential energy versus internuclear distance ( $d$ ) of  $\text{H}_2$  molecule in the electronic ground state. What is the value of the net potential energy  $E_0$  (as indicated in the figure) in  $\text{kJ mol}^{-1}$ , for  $d = d_0$  at which the electron-electron repulsion and the nucleus-nucleus repulsion energies are absent? As reference, the potential energy of H atom is taken as zero when its electron and the nucleus are infinitely far apart.  
 Use Avogadro constant as  $6.023 \times 10^{23} \text{ mol}^{-1}$ .



- Q.16 Consider the reaction sequence from **P** to **Q** shown below. The overall yield of the major product **Q** from **P** is 75%. What is the amount in grams of **Q** obtained from 9.3 mL of **P**? (Use density of **P** = 1.00 g mL<sup>-1</sup>; Molar mass of C = 12.0, H = 1.0, O = 16.0 and N = 14.0 g mol<sup>-1</sup>)



- Q.17 Tin is obtained from cassiterite by reduction with coke. Use the data given below to determine the minimum temperature (in K) at which the reduction of cassiterite by coke would take place.  
 At 298 K:  $\Delta_f H^0(\text{SnO}_2(s)) = -581.0 \text{ kJ mol}^{-1}$ ,  $\Delta_f H^0(\text{CO}_2(g)) = -394.0 \text{ kJ mol}^{-1}$ ,  
 $S^0(\text{SnO}_2(s)) = 56.0 \text{ J K}^{-1} \text{ mol}^{-1}$ ,  $S^0(\text{Sn}(s)) = 52.0 \text{ J K}^{-1} \text{ mol}^{-1}$ ,  
 $S^0(\text{C}(s)) = 6.0 \text{ J K}^{-1} \text{ mol}^{-1}$ ,  $S^0(\text{CO}_2(g)) = 210.0 \text{ J K}^{-1} \text{ mol}^{-1}$ .  
 Assume that the enthalpies and the entropies are temperature independent.
- Q.18 An acidified solution of 0.05 M Zn<sup>2+</sup> is saturated with 0.1 M H<sub>2</sub>S. What is the minimum molar concentration (M) of H<sup>+</sup> required to prevent the precipitation of ZnS?  
 Use  $K_{\text{sp}}(\text{ZnS}) = 1.25 \times 10^{-22}$  and  
 overall dissociation constant of H<sub>2</sub>S,  $K_{\text{NET}} = K_1 K_2 = 1 \times 10^{-21}$ .

**END OF THE QUESTION PAPER**