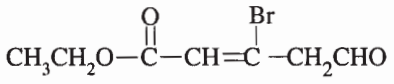
2.1.2 Paper I

1. The highest oxidation state and the outer electron configuration of the ground state of chromium respectively are
   (1) +3 and $[Ar]3d^4 4s^2$ (2) +4 and $[Ar]3d^5 4s^1$ (3) +6 and $[Ar]3d^4 4s^2$
   (4) +4 and $[Ar]3d^6 4s^0$ (5) +6 and $[Ar]3d^5 4s^1$

2. The **increasing** order of the first ionization energy of atoms N, Ne, Na, P, Ar and K is
   (1) Na < K < P < N < Ar < Ne (2) Na < K < Ar < N < P < Ne
   (3) P < N < K < Na < Ne < Ar (4) K < Na < N < P < Ne < Ar
   (5) K < Na < P < N < Ar < Ne

3. What is the IUPAC name of the following compound?



   (1) 3–bromo–5–ethoxy–5–oxo–3–pentenal (2) ethyl–3–bromo–5–oxopent–2–enoate
   (3) ethyl 3–bromo–2–en–5–oxopentanoate (4) ethyl 3–bromo–5–oxo–2–pentenoate
   (5) 3–bromo–1–ethoxy–5–oxo–2–pentenal

4. When the compound **X** having C, H, O only was treated with excess acetylchloride a compound having a relative molecular mass 126 units higher than that of **X** was obtained. The number of hydroxyl groups in **X** is
   (1) 1 (2) 2 (3) 3 (4) 4 (5) 5

5. The number of atomic orbitals possible for which the quantum numbers $n = 3$ and $m_l = -1$ is
   (1) 1 (2) 2 (3) 3 (4) 4 (5) 5

6. The electron pair geometry and the molecular shape of XeO_2F_2 respectively, are
   (1) trigonal bipyramid and see-saw. (2) trigonal bipyramid and tetrahedral.
   (3) tetrahedral and see-saw. (4) see-saw and trigonal bipyramid.
   (5) square planar and tetrahedral.

7. A mixture of Fe_2O_3 and FeO is found to contain 72.0% Fe by mass. The mass of Fe_2O_3 in 1.0 g of this mixture is (O = 16, Fe = 56)
   (1) 0.37 g (2) 0.52 g (3) 0.67 g (4) 0.74 g (5) 0.83 g

8. Samples of $F_2(g)$ and Xe(g) are mixed in a container of fixed volume. The partial pressures of $F_2(g)$ and Xe(g) before they react are 8.0×10^{-5} kPa and 1.7×10^{-5} kPa respectively. When all of the Xe(g) has reacted, forming a solid compound, the partial pressure of the remaining $F_2(g)$ was 4.6×10^{-5} kPa. The system was maintained at a constant temperature during the above process. What is the formula of the solid compound formed?
   (1) XeF_2 (2) XeF_3 (3) XeF_4 (4) XeF_6 (5) XeF_8

9. When an inorganic solid **X** was treated with dil. HCl, a colourless solution and a gas that turned a filter paper moistened with lead acetate solution black were produced. When the colourless solution was subjected to the flame test, an apple green coloured flame was observed.
   Solid **X** is
   (1) BaS (2) $CuSO_3$ (3) $BaSO_3$ (4) NiS (5) $CuCO_3$

10. Which of the following statements is **false** with regard to hypochlorous acid (HOCl) ?
    (1) HOCl is a weak acid.
    (2) The oxidation state of chlorine in HOCl is –1.
    (3) I_2 is produced when KI is added to an aqueous solution of HOCl.
    (4) In basic solution HOCl disproportionates on heating.
    (5) HOCl reacts with alkali to form salts called hyprochlorites.

11. A volume of 50.00 cm^3 of 0.01 mol dm^{-3} NaOH solution was added to 50.00 cm^3 of 0.11 mol dm^{-3} solution of the weak acid HA. The pH of the final mixture was found to be 6.2. If K_a is the dissociation constant of the acid, which of the following answers indicates its pK_a value?
    (1) 5.2 (2) 6.0 (3) 6.2 (4) 7.0 (5) 7.2

12. The IUPAC name of $[Co(CN)_2(NH_3)_4]^+$ is
(1) tetraammoniadicyanocobalt(III) ion
(2) tetraamminedicyanocobalt(III) ion
(3) dicyanotetraamminecobalt(III) ion
(4) tetraamminedicyanidecobalt(III) ion
(5) tetraaminedicyanocobalt(III) ion

13. A 50.00 cm^3 sample of a solution containing Fe^{2+} is titrated with 0.02 M $K_2Cr_2O_7$ in acidic medium. The volume of $K_2Cr_2O_7$ required to react all the Fe^{2+} is 25.00 cm^3. If this titration is carried out using 0.02 M $KMnO_4$ instead of 0.02 M $K_2Cr_2O_7$, the volume of $KMnO_4$ required is
(1) 22.00 cm^3 (2) 23.00 cm^3 (3) 25.00 cm^3 (4) 27.00 cm^3 (5) 30.00 cm^3

14. Consider the following elementary reaction.

$$\mathbf{A}(g) + \mathbf{B}(g) \longrightarrow \mathbf{C}(g)$$

The rate constant of the reaction at temperature T is k. n mol of **A** and n mol of **B** were mixed and allowed to react in a rigid container of volume V. If the universal gas constant is R, and the rate of reaction at time t is Q, the pressure (P) of the vessel at time t is given by

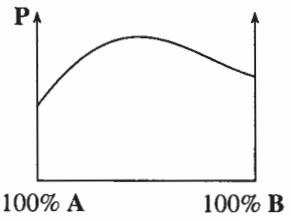
(1) $P = Q^2 \frac{RT}{V}$ (2) $P = \left[\frac{n}{V} + \left(\frac{Q}{k}\right)^{\frac{1}{2}}\right]RT$ (3) $P = \frac{Q}{k}\frac{RT}{V}$

(4) $P = \left(\frac{n}{V} + \frac{Q}{k}\right)RT$ (5) $P = \frac{2n\,RT}{V}$

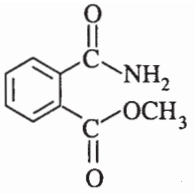
15. Volatile liquids **A** and **B** form an ideal solution when mixed. It was observed that the pressure of the vapour phase, which is in equilibrium with the liquid phase was doubled when the composition in the liquid phase was changed from $X_A = 0.2$, $X_B = 0.8$ to $X_A = 0.6$ and $X_B = 0.4$. The system was maintained at a constant temperature during the above process. The saturated vapour pressures of **A** and **B** at this temperature are P_A° and P_B° respectively. Which of the following relationships is **correct**?

(1) $\frac{P_A^\circ}{P_B^\circ} = 6$ (2) $P_A^\circ + P_B^\circ = \frac{1}{2}$ (3) $\frac{P_A^\circ}{P_B^\circ} = \frac{4}{3}$ (4) $\frac{P_A^\circ}{P_B^\circ} = \frac{3}{4}$ (5) $\frac{P_A^\circ}{P_B^\circ} = \frac{1}{6}$

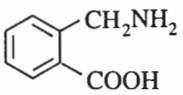
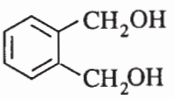
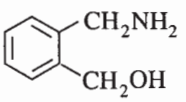
16. The variation of vapour pressure (**P**) with composition of a mixture of two miscible liquids **A** and **B** is shown in the figure.

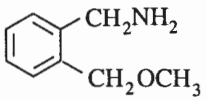
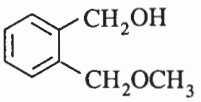


Which of the following answers is **true** about the intermolecular attractive forces?
(1) **A – A < A – B < B – B** (2) **A – A > A – B > B – B**
(3) **A – A < A – B > B – B** (4) **A – A > A – B < B – B**
(5) **A – A = A – B = B – B**

17. 

What is the **major** product obtained when the compound above is treated with $LiAlH_4$ and the reaction mixture is neutralized?

(1)  (2)  (3) 

(4)  (5) 

18. Consider the following equilibria with equilibrium constants K_1, K_2 and K_3 respectively.

$$A(g) + B(g) \rightleftharpoons C(g)$$
$$C(g) + A(g) \rightleftharpoons D(g)$$
$$2A(g) + B(g) \rightleftharpoons D(g)$$

Which of the following equations shows the relationship among the three equilibrium constants?

(1) $K_3 = K_1 + K_2$ (2) $K_3 = \sqrt{K_1 K_2}$ (3) $K_3 = \frac{1}{K_1 K_2}$ (4) $K_3 = K_1 K_2$ (5) $K_3 = K_1 - K_2$

19. Which of the following arrangements shows the correct **increasing** order of pH of the following 1 M aqueous solutions?

HCl, KOH, $CaCl_2$, CH_3COOH, $CH_3COO^-Na^+$

(1) $KOH < CaCl_2 < CH_3COO^-Na^+ < CH_3COOH < HCl$
(2) $HCl < CaCl_2 < CH_3COOH < KOH < CH_3COO^-Na^+$
(3) $CH_3COOH < HCl < CaCl_2 < KOH < CH_3COO^-Na^+$
(4) $HCl < CH_3COOH < CH_3COO^-Na^+ < CaCl_2 < KOH$
(5) $HCl < CH_3COOH < CaCl_2 < CH_3COO^-Na^+ < KOH$

20. What is the total number of resonance structures that can be drawn for the HN_3 molecule? (Skeleton of the molecule, H—N—N—N)

(1) 2 (2) 3 (3) 4 (4) 5 (5) 6

21. Which of the following statements with regard to 3*d*-block transition elements is **false**?

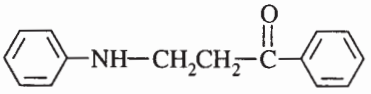
(1) Variable oxidation states result because of the comparable energies of 3*d* and 4*s* atomic orbitals.
(2) The electronegativity gradually decreases across the period from left to right.
(3) They have stronger metallic characteristics than those belonging to the *s*-block of the same period.
(4) Many ionic and covalent compounds of transition metals are coloured.
(5) Their densities are higher than the *s*-block elements of the same period.

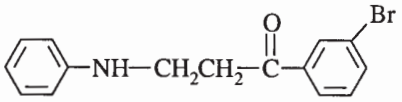
22. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

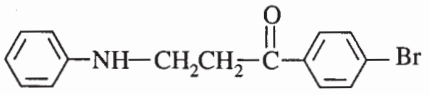
The reaction above is thermodynamically spontaneous at 298 K, but not so at high temperature. Which of the following is **true** about the reaction at 298 K?

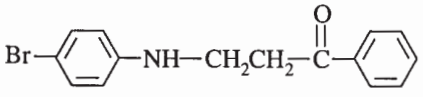
(1) ΔG, ΔH and ΔS all are positive.
(2) ΔG, ΔH and ΔS all are negative.
(3) ΔG and ΔH are negative and ΔS is positive.
(4) ΔG and ΔS are negative and ΔH is positive.
(5) ΔG and ΔH are positive and ΔS is negative.

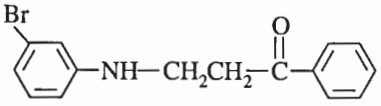
23. Predict the **major** product that will be obtained from the bromination of the following compound with $Br_2/FeBr_3$.

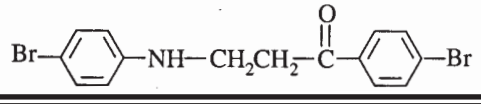


(1) 

(2) 

(3) 

(4) 

(5) 

24. Which of the following reactions is **not** likely to take place during chlorination of methane in the presence of light?

(1) $Cl-Cl \longrightarrow 2\,\dot{Cl}$

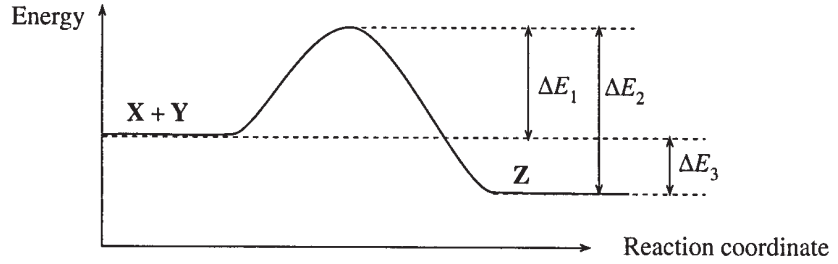
(2) $CH_4 + \dot{Cl} \longrightarrow CH_3Cl + \dot{H}$

(3) $CH_4 + \dot{Cl} \longrightarrow \dot{C}H_3 + HCl$

(4) $\dot{C}H_3 + Cl_2 \longrightarrow CH_3Cl + \dot{Cl}$

(5) $\dot{C}H_3 + \dot{Cl} \longrightarrow CH_3Cl$

25. The energy diagram for the reaction **X** + **Y** → **Z** is shown below.



The rate of this reaction is dependent on

(1) ΔE_1 only. (2) ΔE_2 only. (3) ΔE_3 only.

(4) $\Delta E_1 + \Delta E_2$. (5) $\Delta E_2 + \Delta E_3$.

26. Which of the following statements is **false** with regard to *s*-block elements?

(1) Group I elements are strong oxidizing agents.
(2) Group I elements have the lowest first ionisation energy values in a period.
(3) Group II elements are smaller than the corresponding Group I elements.
(4) In general, Groups I and II elements form ionic compounds.
(5) Group II elements are harder and have higher melting points than those of Group I.

27. Which of the following statements regarding ammonia (NH_3) is **false**?

(1) The oxidation state of N in NH_3 is −3.
(2) NH_3 gives a pink colour with Nessler's reagent.
(3) NH_3 is used as one of the raw materials in the manufacture of nitric acid.
(4) NH_3 is used to remove the acidic constituents in crude oil.
(5) NH_3 is produced on heating $NaNO_3$ with Al powder and aqueous NaOH.

28. Which of the following statements with regard to molecular oxygen (O_2) and ozone (O_3) is **false**?

(1) Molecular oxygen and ozone are allotropes.
(2) In the lower atmosphere photochemical reactions generate ozone from molecular oxygen.
(3) The O—O bond length of ozone is greater than the O—O bond length of molecular oxygen.
(4) Both molecular oxygen and ozone are greenhouse gases.
(5) Since molecular oxygen and ozone absorb UV radiation in the upper atmosphere, human life on earth is protected.

29. A 25.00 cm^3 volume of aqueous $CuSO_4$ solution is electrolysed using two platinum electrodes. The current during the electrolysis was kept at 10^{-2} A and it took 9.65 seconds to deposit all the Cu^{2+} as Cu on the cathode. What is the concentration of Cu^{2+} in the solution? (1 F = 96 500 C mol^{-1})

(1) 1×10^{-5} M (2) 2×10^{-5} M (3) 4×10^{-5} M (4) 5×10^{-5} M (5) 1×10^{-4} M

30. A solid sample contains only $CaCO_3$ and $MgCO_3$. To completely react the $CaCO_3$ and $MgCO_3$ present in the sample, 42.00 cm^3 of 0.088 M HCl were required. The anhydrous chloride salts from the reaction, obtained by evaporation of the filtrate weighed 0.19 g. The mass of $CaCO_3$ present in the solid sample is
(C = 12, O = 16, Mg = 24, Ca = 40, Cl = 35.5)

(1) 0.05 g (2) 0.07 g (3) 0.09 g (4) 0.11 g (5) 0.12 g

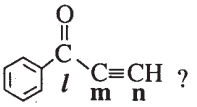
● For each of the questions **31** to **40**, one or more responses out of the four responses (*a*), (*b*), (*c*) and (*d*) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

(1) if only (*a*) and (*b*) are correct.
(2) if only (*b*) and (*c*) are correct.
(3) if only (*c*) and (*d*) are correct.
(4) if only (*d*) and (*a*) are correct.
(5) if **any other** number or combination of responses is correct.

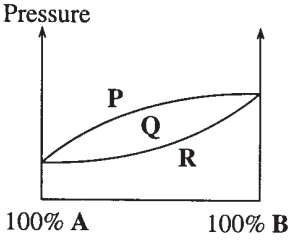
Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only (*a*) and (*b*) are correct	Only (*b*) and (*c*) are correct	Only (*c*) and (*d*) are correct	Only (*d*) and (*a*) are correct	**Any other** number or combination of responses is correct

31. Values of E° for the Ce^{4+}/Ce^{3+} and Fe^{2+}/Fe are +1.72 V and –0.44 V respectively. According to these data which of the following statements is/are **true**?
(*a*) Ce^{4+} is a weaker oxidizing agent than Fe^{2+}.
(*b*) Ce^{4+} will reduce Fe^{2+}.
(*c*) Ce^{4+} is a better oxidizing agent than Fe^{2+}.
(*d*) Ce^{4+} will oxidize Fe.

32. Which of the following statements is/are **true** regarding the molecule  ?
(*a*) All carbon atoms are sp^2 hybridized.
(*b*) Carbon atoms labelled as ***l***, **m** and **n** and the oxygen atom lie in the same plane.
(*c*) All C—H bonds are equal in length.
(*d*) Carbon atoms labelled as ***l***, **m** and **n** lie in a straight line.

33. Shown below is the constant temperature phase diagram of **A** and **B**, which form an ideal solution.



Which of the following statements is/are **true**?
(*a*) The boiling point of compound **A** is higher than the boiling point of compound **B**.
(*b*) The vapour phase and liquid phase exist in equilibrium in the region **Q**.
(*c*) Only the vapour phase exists in the region **P**.
(*d*) Only the liquid phase exists in the region **R**.

34. Which of the following statements is/are **true** regarding polymers?
(*a*) Natural rubber has double bonds with *cis* configuration.
(*b*) Polyvinyl Chloride (PVC) is formed by addition polymerization of CHCl=CHCl.
(*c*) Polystyrene and nylon are both prepared by condensation polymerization.
(*d*) Both urea-formaldehyde and phenol-formaldehyde polymers contain $\rangle C = O$ groups in their structures.

35. The gases **A** and **B** react to form the product **P**. The material **X** in fine particle form, has been suggested for use as a catalyst for this reaction. The material **X** provides an alternative mechanism consisting of three steps. The activation energies for the three steps and for the reaction without **X** are given below.

	Activation energy / kJ mol^{-1}
Without **X**	50
With **X** step I	10
With **X** step II	5
With **X** step III	50

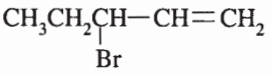
Which of the following statements is/are **true**?

(*a*) Use of **X** will not change the reaction rate significantly.
(*b*) Activation energy in step III can be lowered by using more **X**.
(*c*) Use of **X** increases the rate of the reaction because **X** is a material with a large surface area.
(*d*) Increasing of temperature will increase the reaction rate, regardless of whether **X** is used or not.

36. Which of the following statements is/are **true** regarding phenol?

(*a*) Phenol reacts readily with formaldehyde in acidic or basic medium.
(*b*) Phenol is less acidic than ethanol.
(*c*) Phenol reacts with aq. $NaHCO_3$ and gives CO_2.
(*d*) Phenol undergoes a substitution reaction with Br_2.

37. Which of the following statements is/are **true** regarding the compound represented by the structure given below?



(*a*) It can exist in two stereoisomeric forms.
(*b*) Catalytic hydrogenation of it gives a compound which does not show stereoisomerism.
(*c*) Treatment of it with alcoholic KOH gives a compound which does not show stereoisomerism.
(*d*) Treatment of it with aqueous KOH gives a compound which does not show stereoisomerism.

38. ΔH and ΔG data at temperature T are provided for the following reactions.

I. $2CH_4(g) \longrightarrow C_2H_4(g) + 2H_2(g)$ $\quad \Delta H = 201.88$ kJ mol^{-1}; $\Delta G = 169.62$ kJ mol^{-1}

II. $2CH_4(g) + O_2(g) \longrightarrow C_2H_4(g) + 2H_2O(g)$ $\quad \Delta H = -281.76$ kJ mol^{-1}; $\Delta G = -287.56$ kJ mol^{-1}

III. $2CH_4(g) + 2C(s) \longrightarrow 2C_2H_4(g)$ $\quad \Delta H = 254.14$ kJ mol^{-1}; $\Delta G = 237.74$ kJ mol^{-1}

Which of the following statements is/are **true** at temperature T?

(*a*) All three reactions I, II and III could be used to produce C_2H_4 from CH_4.
(*b*) Reaction I has a negative entropy change.
(*c*) Reaction II is the only feasible reaction for producing C_2H_4 from CH_4.
(*d*) Reaction III has a positive entropy change.

39. During cation analysis, Group I metal ions are precipitated as chlorides. Which of the following statements is/are **true** regarding the Group I analysis?

(*a*) Ag^+, Hg^{2+}, Hg_2^{2+} and Pb^{2+} form insoluble chlorides with the addition of dil. HCl.
(*b*) Only AgCl and $PbCl_2$ dissolve in aqueous NH_3 and will not reprecipitate with the addition of dil. HCl.
(*c*) Only Ag^+, Hg_2^{2+} and Pb^{2+} form insoluble chlorides with the addition of dil. HCl.
(*d*) Pb^{2+} does not precipitate in hot conc. HCl.

40. Which of the following statements is/are **false** with regard to H_2O_2?

(*a*) In the H_2O_2 molecule, the two hydroxyl groups lie in the same plane.
(*b*) H_2O_2 can act both as an oxidizing agent and a reducing agent in both acidic and basic media.
(*c*) Pure H_2O_2 is a colourless, strongly hydrogen bonded liquid.
(*d*) The oxygen atoms in H_2O_2 are *sp* hybridized.

- In question Nos. **41** to **50**, two statements are given in respect of each question.
  From the Table given below, select the response out of the responses (1), (2), (3), (4) and (5) that **best** fits the two statements and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does **not** explain the first statement correctly.
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second Statement
41.	All emissions end up at $n = 1$ for the Balmer series in the hydrogen spectrum.	The Bohr model is used to explain the origin of the hydrogen spectrum.
42.	2–Butanone (MW 72) has a higher boiling point than that of pentane (MW 72).	There are no hydrogen bonds between pentane molecules.
43.	2–Methyl–1–propanol gives a turbidity with conc. $HCl/ZnCl_2$ much faster than does 2–methyl–2–propanol.	Tertiary carbocations are more stable than primary carbocations.
44.	$CaCO_3(s)$ does not decompose to $CO_2(g)$ and $CaO(s)$ at room temperature, but it could be decomposed by increasing the temperature.	Gibbs energy change of a reaction can always be made negative by increasing the temperature.
45.	Intermolecular forces between SO_2 molecules are stronger than those between CO_2 molecules.	Intermolecular forces between polar molecules are stronger than those between non-polar molecules of similar mass.
46.	$CH_3-\overset{\overset{O}{\|}}{C}-CH_2CH_3$ and $CH_2=\overset{\overset{OH}{\|}}{C}-CH_2CH_3$ are two reasonance structures of the same compound.	The number of double bonds in resonance structures of a given compound should be the same.
47.	At constant temperature, doubling the concentration of all the reactants in the elementary reaction $2A + B \longrightarrow 3D + E$ increases the rate by a factor of 8.	In an elementary reaction, the order with respect to a reactant is equal to its stoichiometric coefficient.
48.	In the extraction of iron, the reduction of haematite by CO takes place in three stages.	The temperature of the blast furnace used in the extraction of iron decreases from top to bottom.
49.	Increasing the temperature will always increase the reaction rate.	The activation energy of a reaction decreases when the temperature is increased.
50.	Ammonia and carbon monoxide are used as raw materials in the manufacture of urea.	Ammonium carbonate formed by the reaction of ammonia and carbon monoxide, decomposes to give urea.