TIME: 2 hours

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer **six** questions.

Answer **two** questions from Section A, **one** question from Section B, **two** questions from Section C and **one** other question chosen from any section.

Write your answers on the separate answer paper provided.

If you use more than one sheet of paper, fasten the sheets together.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

Section A

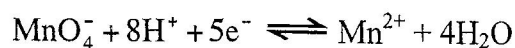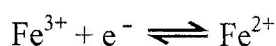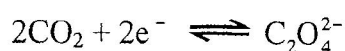*Answer at least **two** questions from this section.*

1 **(a)** Define the term *relative isotopic mass*. [1]

(b) An analysis of the composition of a newly discovered element, Q, showed the following results

Isotope	Relative abundance (%)
^{20}Q	90.91
^{21}Q	0.16
^{22}Q	8.93

On the mass spectrum of Q, the peak due to isotope ^{21}Q had a peak of 0.20 cm.

(i) Deduce the heights of the other two peaks.

(ii) Draw a sketch of the mass spectrum of Q in terms of these heights.

(iii) Calculate the relative atomic mass of Q.

[4]

(c) A 1.50 g sample of anhydrous iron (II) ethane-dioate, FeC_2O_4, was dissolved in 100.00 cm^3 of water. A 25.00 cm^3 sample of the solution required 15.00 cm^3 of $KMnO_{4(aq)}$ for a complete reaction titration.

(i) Use the following half equations to write the overall equation for the oxidation of FeC_2O_4 by $KMnO_4$.

$$2CO_2 + 2e^- \rightleftharpoons C_2O_4^{2-}$$

$$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$$

$$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$$

(ii) Calculate the concentration of $KMnO_{4(aq)}$. [7]

[Total: 12]

2 **(a)** Define an *acid-base indicator*. [1]

(b) If an indicator can be conveniently represented as HIn and its equilibrium dissociation constant as KIn, write

  (i) the equation for the dissociation of HIn in aqueous solution,

  (ii) an expression for KIn. [2]

(c) Congo red, an acid base indicator, is blue in acidic conditions and red in alkaline conditions. It has a KIn value of 1.2×10^{-4} moldm^{-3}.

  (i) Given that colour change begins when $[\text{In}^-] = [\text{HIn}]$, calculate the pH at which Congo red begins to change colour.

  (ii) State the acid-base titrations for which Congo red would be most suitable.

  (iii) Calculate the pH of a 0.2 moldm^{-3} solution of Congo red.

  (iv) If an Indicator contributes to the pH of a solution, suggest a reason why the pH of a titration mixture is not affected by the Indicator used. [5]

(d) The pH changes during the titration of acid **HA** against base **HB** are shown in **Table 1**.

Table 1

| Volume of base HB/cm^3	0	5	10	15	20	22	25	30
pH	0.8	1.0	1.6	2.4	3.6	8.0	9.0	9.6

  (i) Plot a graph of pH against volume of base **HB**.

  (ii) Use your graph to deduce the pH at end point. [4]

[Total: 12]

[Turn over

3 **(a)** **(i)** Explain the *phrase mechanism of a reaction.*

(ii) Suggest **one** reason why the study of reaction kinetics is of importance to chemists.

[2]

(b) The reaction between two gases **A** and **B** is represented by the equation:

$$2A + B \rightarrow A_2B$$
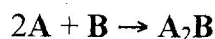
Two experiments were carried out in which the change in the partial pressure of each gas with time was monitored.

The results obtained are shown in the tables:

Experiment 1: Change in partial pressure of **A** with time

Time/s	0	600	1 200	1 800	2 400
Partial pressure of A/atm	0.500	0.250	0.170	0.125	0.080

Experiment 2: Change in Partial pressure of **B** with time

Time/s	0	600	1 200	1 800	2 400
Partial pressure of B/atm	0.450	0.375	0.300	0.225	0.150

(i) On the same axes plot graphs of change in partial pressure against time for each reactant. Label each graph.

(ii) Use your graphs to deduce the order of reaction with respect to:

1. **A**

2. **B**

(iii) Suggest a suitable mechanism for the reaction.

[10]
[Total: 12]

5

Section B

*Answer at least **one** question from this section.*

4 (a) (i) Sketch graphs of variation in melting points of the substances listed below:

1. sodium, magnesium, aluminium and silicon.

2. sodium chloride, magnesium chloride, aluminium chloride and silicon tetrachloride.

(ii) Explain the trends in the melting points shown in each graph in terms of structure and bonding. [7]

(b) A Period (III) element, X, has a melting point of 119°C. It forms two acidic oxides. Its mass spectrum shows several lines, the last corresponding to an m/e value of 256.

(i) Identify X.

(ii) Account for the line at m/e 256.

(iii) X forms several oxy anions one of which has the formula $X_2O_3^{2-}$. $X_2O_3^{2-}$ reduces Cl_2 to Cl^-, a reaction in which the oxidation state of X changes by four units.

It also reduces I_2 to I^-, in which the oxidation state of X changes by 0.5 units.

When treated with a dilute acid $X_2O_3^{2-}$ liberates X and one of its acidic oxides.

Write equations for

1. the reduction of Cl_2 by $X_2O_3^{2-}$,

2. the reduction of I_2 by $X_2O_3^{2-}$,

3. the reaction of $X_2O_3^{2-}$ with a dilute acid.

[5]
[Total: 12]

5 **(a)** Nitrogen is an unreactive gaseous element whereas phospshorous forms a white solid that ignites spontaneously at 35°C.

    (i)   Explain

        1.   the unreactivity of nitrogen,

        2.   the differences in physical states of the two elements.

    (ii) Write equations for the

        1.   combustion of phosphorous

        2.   reaction of the product of combustion with water.

                                            [5]

(b) Ammonia is largely used in the making of fertilisers, explosives and dyes.

    (i)   State any **two** other uses of ammonia.

    (ii) Write a balanced equation to show the formation of ammonia by the hydrolysis of magnesium nitride, Mg_3N_2.

                                            [3]

(c) The ammonium ion is produced when ammonia forms a datative bond with a hydrogen ion. It differs from ammonia in shape, physical and chemical properties.

    (i)   Draw and name the shape of

        1.   ammonia,

        2.   the ammonium ion.

    (ii) State **one** difference in

        1.   physical properties,

        2.   chemical properties of ammonia and ammonium chloride.

                                            [4]

                                    [Total: 12]

Section C

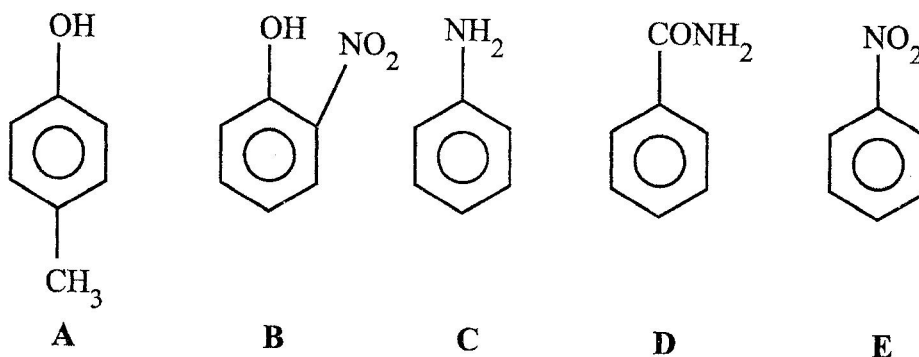*Answer at least **two** questions from this section.*

6   **Fig. 1** shows organic compounds **A**, **B**, **C**, **D** and **E**.

Fig. 1

(a)   State, with a reason, the compound that is

    (i)   most acidic,

    (ii)   most basic,

    (iii) neutral.

[3]

(b)   Compare the reactions of **C** and **E** with bromine by

    (i)   stating conditions for each reaction,

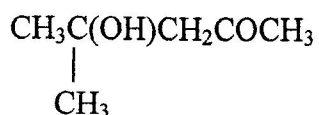   **(ii)**   giving the structural formula of the organic product.

[4]

(c)   Two of the compounds react to form a dye in a two step reaction.

    (i)   Write the **two step** reaction scheme to show formation of the dye.

    (ii)   Give reagents and conditions for step one.

[5]
[Total: 12]

[Turn over

7   The structural formula of an organic compound **A** is shown below

$$CH_3C(OH)CH_2COCH_3$$
$$|$$
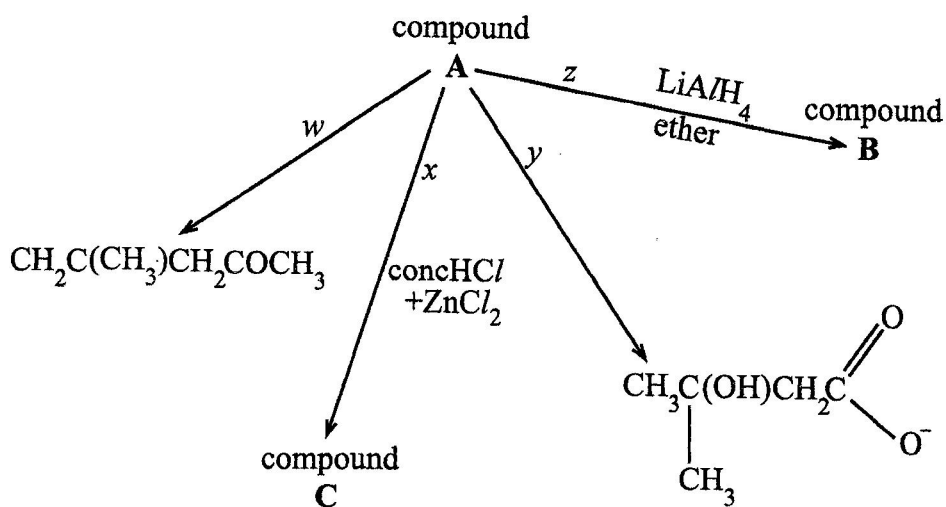$$CH_3$$

(a)   **(i)**   Name compound **A**.

(ii)   Draw the skeletal formula of **A**.

[2]

(b)   **(i)**   Name the **two** types of isomers in which the isomers of **A** have the same structural formula but differ in orientation of atoms in space.

(ii)   Suggest structural formula of isomers of **A**, with five carbon atoms in the parent chain, that would exhibit

1.   optical isomerism,

2.   geometric isomerism.

[4]

(c)   Compound **A** undergoes the reactions shown.

compound
A z $\dfrac{LiAlH_4}{ether}$ compound **B**

w

x y

$CH_2C(CH_3)CH_2COCH_3$ | concHCl +ZnCl_2

$CH_3C(OH)CH_2C\!\!\begin{array}{c}\diagup O\\[-4pt]\diagdown O^-\end{array}$
$|$
CH_3

compound
C

(i)   Give reaction conditions for steps

1. w,

2. y.

(ii)   Draw the structural formula of

1.   **B**,

2.   **C**.

(iii) Describe the observation made when reaction x occurs.

(iv) Suggest an explanation for the observation in (c)(iii).

[6]
[Total: 12]

8 (a) Explain

(i) the solubility of amines in water,

(ii) why higher members of amines are less soluble in water,

(iii) why higher members of amines are less odorous.

[3]

(b) The table shows pK_b values of phenylamine and methylamaine.

	pK_b value
phenylamine	9.30
methylamine	3.36

(i) With the aid of an equation explain the basicity of amines.

(ii) Explain the differences in the pK_b values of phenylamine and methylamine.

[5]

(c) A basic nitrogen compound of the formula $C_8H_{11}N$ reacts with benzene diazonium chloride to give an orange precipitate. It does not react with potassium manganate (VII) but decolourises bromine water giving a white precipitate.

(i) Suggest a structural formula for $C_8H_{11}N$.

(ii) State the conditions used in the reaction with benzene diazonium chloride.

(iii) Write the equations for the reactions described, giving full structural formulae of products formed.

[4]
[Total: 12]