DIPLOMA PROGRAMME

MOCK EXAMINATION

2020

Name :

CHEMISTRY

HIGHER LEVEL

PAPER 2

2 hours 15 minutes

INSTRUCTIONS TO CANDIDATES

- **Do not open this examination paper until instructed to do so.**
- **Answer all questions. Attempt only one question from options of question number 9.**
- **Write your answers in the boxes provided.**
- **A calculator is required for this paper.**
- **A clean copy of the Chemistry data booklet is required for this paper.**
- **The maximum mark for this examination paper is [90 marks]**

1a. After heating 3.760 g of a silver oxide 3.275 g of silver remained. Determine the empirical formula of Ag_xO_y.

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[2 marks]

1b. Suggest why the final mass of solid obtained by heating 3.760 g of Ag_xO_y may be greater than 3.275 g giving one design improvement for your proposed suggestion. Ignore any possible errors in the weighing procedure.

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[2 marks]

1c. Naturally occurring silver is composed of two stable isotopes, ^{107}Ag and ^{109}Ag.

The relative atomic mass of silver is 107.87. Show that isotope ^{107}Ag is more abundant.

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[1 mark]

1d. Some oxides of period 3, such as Na_2O and P_4O_{10}, react with water. A spatula measure of each oxide was added to a separate 100 cm^3 flask containing distilled water and a few drops of bromothymol blue indicator.

The indicator is listed in section 22 of the data booklet.

Deduce the colour of the resulting solution and the chemical formula of the product formed after reaction with water for each oxide.

Flask containing	Colour of solution	Product formula
Na_2O	. . . . .	. . . . .
P_4O_{10}	. . . . .	. . . . .

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[3 marks]

1e. Explain the electrical conductivity of molten Na_2O and P_4O_{10}.

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[2 marks]

1f. Outline the model of electron configuration deduced from the hydrogen line emission spectrum (Bohr's model).

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[2 marks]

2a. State the nuclear symbol notation, ${}^{A}_{Z}X$, for magnesium-26.

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[1 mark]

2b. Mass spectroscopic analysis of a sample of magnesium gave the following results:

	% abundance
Mg-24	78.60
Mg-25	10.11
Mg-26	11.29

Calculate the relative atomic mass, A_r, of this sample of magnesium to two decimal places.

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[2 marks]

2c. Magnesium burns in air to form a white compound, magnesium oxide. Formulate an equation for the reaction of magnesium oxide with water.

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[1 mark]

2d. Describe the trend in acid-base properties of the oxides of period 3, sodium to chlorine.

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[2 marks]

2e. In addition to magnesium oxide, magnesium forms another compound when burned in air. Suggest the formula of this compound

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[1 mark]

2f. Describe the structure and bonding in solid magnesium oxide.

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[2 marks]

2g. Magnesium chloride can be electrolysed.

Deduce the half-equations for the reactions at each electrode when **molten** magnesium chloride is electrolysed, showing the state symbols of the products. The melting points of magnesium and magnesium chloride are 922 K and 987 K respectively.

Anode (positive electrode):

Cathode (negative electrode):

[2 marks]

3 $2SO_{3(g)} \rightarrow 2SO_{2(g)} + O_{2(g)}$

3a. Deduce the equilibrium constant expression, K_c, for the reaction.

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[1 mark]

3b. State and explain the effect of increasing the temperature on the yield of sulfur trioxide.

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[2 marks]

3c. State the effect of a catalyst on the value of K_c.

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[1 mark]

3d. State and explain the effect of a catalyst on the position of equilibrium.

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[2 marks]

4a. Define *oxidation* in terms of oxidation numbers.

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[1 mark]

4b. Describe using a labelled diagram, the essential components of an electrolytic cell.

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[3 marks]

4c. Explain why solid sodium chloride does not conduct electricity but **molten** sodium chloride does.

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[2 marks]

4d. Molten sodium chloride undergoes electrolysis in an electrolytic cell. For each electrode deduce the half-equation and state whether oxidation or reduction takes place. Deduce the equation of the overall cell reaction including state symbols.

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[5 marks]

4e. Electrolysis has made it possible to obtain reactive metals such as aluminium from their ores, which has resulted in significant developments in engineering and technology. State **one** reason why aluminium is preferred to iron in many uses.

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[1 mark]

4f. Outline **two** differences between an electrolytic cell and a voltaic cell.

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[2 marks]

5 (a) Explain the meaning of the term *hybridization*.

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(1)

(b) State the type of hybridization shown by the carbon atom in the H–C≡N molecule, and the number of σ and π bonds present in the C≡N bond.

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(2)

(c) Describe how σ and π bonds form.

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(4)
(Total 7 marks)

6. Consider the following reaction.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

(i) Use values from Table 10 in the Data Booklet to calculate the enthalpy change, $\Delta H^{\ominus}$, for this reaction.

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(3)

(ii) The magnitude of the entropy change, ΔS, at 27°C for the reaction is 62.7 J K^{-1} mol^{-1}. State, with a reason, the sign of ΔS.

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(2)

(iii) Calculate ΔG for the reaction at 27°C and determine whether this reaction is spontaneous at this temperature.

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(3)
(Total 8 marks)

7. (a) The variation of the rate constant, k, for a reaction with temperature is shown by the Arrhenius equation. Two versions of this equation are shown in the Data Booklet.

(i) Explain the significance of the Arrhenius constant, A, in this equation. (1)

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(ii) Explain what is meant by the term *activation energy,* E_a. (1)

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(iii) Describe how, using a graphical method, values of A and E_a can be obtained for a reaction. (3)

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(b) The equation for a reaction used in industry is

$CH_2CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl \qquad \Delta H^{\ominus} = -185$ kJ

Iron (III) Chloride can be used as a catalyst for the reaction.

(i) Explain the difference between the terms *homogeneous* and *heterogeneous* when applied to a catalyst.

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……(1)

(ii) Draw an enthalpy level diagram for this reaction, including labels for $\Delta H^{\ominus}$, E_a and the activation energy when a catalyst is used, E_{cat}. (4)

(Total 10 marks)

8. For the following compounds

BCl_3, NH_3, XeF_4

(i) Draw a Lewis structure for each molecule.
(Show all non-bonding electron pairs.)

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(ii) State the shape of each molecule and predict the bond angles.

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(Total 9 marks)

9.A (i) A compound **D** has the molecular formula $C_2H_4O_2$ and is obtained from a reaction between methanoic acid and methanol. Write an equation for this reaction and state the name of **D**.

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(3)

(ii) A second compound, **E**, has the same molecular formula as **D** and has acidic properties.

State the name of compound **E**.

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(1)

9B. Bromoethane reacts with ammonia as follows.

$$CH_3CH_2Br + NH_3 \rightarrow CH_3CH_2NH_3^+ + Br^-$$

$$CH_3CH_2NH_3^+ + NH_3 \rightarrow CH_3CH_2NH_2 + NH_4^+$$

The mechanism for this reaction is described as S_N2.

(a) State the meaning of each of the symbols in S_N2.

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(2)

(b) State the name of the organic product of the reaction, $CH_3CH_2NH_2$.

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(1)

(c) Explain, using "curly arrows" to show the movement of electron pairs, the mechanism of the attack by ammonia on bromoethane, and show the structure of the transition state.

(4)

(d) The compound, 2-Bromobutane, $CH_3CHBrCH_2CH_3$, can react with Sodium Hydroxide to form compounds **F**, **G** and **H**.

Compound **F**, $C_4H_{10}O$, exists as a pair of optical isomers. Compounds **G** and **H**, C_4H_8, are structural isomers, and compound **H** exists as a pair of geometrical isomers.

Draw the structures of the two optical isomers of **F**.

(2)
(Total 13 marks)

OR

9A (i) Define the term pH.

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(ii) State what is meant by the term *buffer solution*, and describe the composition of an acid buffer solution in general terms.

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(ii)

Calculate the pH of a mixture of 50 cm^3 of Ammonia solution of

Concentration 0.10 mol dm^{-3} and 50 cm^3 of Hydrochloric acid solution of

concentration 0.050 mol dm^{-3}.

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9B In aqueous solution at 298 K, ammonia is a weak base with a pK_b value of 4.75 and a K_b value of 1.7×10^{-5} mol dm^{-3}.

(a) Write an equation for the reaction of ammonia with water.

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(1)

(b) State the ionization constant expression, K_b, for ammonia.

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(1)

(c) Calculate the pH of a 0.25 mol dm^{-3} solution of ammonia.

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(3)
(Total 13 marks)