CRANBROOK
SCHOOL

YEAR 12 TRIAL HSC EXAMINATION

2 UNIT HSC COURSE
2012

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your Student Number at the top of the pages indicated

This examination has two parts, Part A and Part B

Part A – 20 marks
- Attempt Questions 1 – 20

Part B – 80 marks
- Attempt Questions 21 – 33

Total marks - 100

THERE IS ONE BOOKLET AND ONE MULTIPLE CHOICE ANSWER SHEET IN THIS EXAMINATION

NO EXTRA PAPER/BOOKLETS ARE REQUIRED IN ADDITION TO THE WRITTEN EXAMINATION BOOKLETS

The content and format of this paper do not necessarily reflect the content and format of the HSC examination paper.

Part A – 20 marks
Attempt Questions 1-20
Allow about 35 minutes for this part

Student Number: ______________________

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ✗ C ○ D ○

If you have changed your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

A ✗ B ✗ ← *correct* C ○ D ○

1.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**11**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**12**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**13**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**14**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**15**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**16**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**17**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**18**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**19**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**20**	Ⓐ	Ⓑ	Ⓒ	Ⓓ

1 Ethanol would be a good solvent for

(A) pentan-1-ol.

(B) petrol.

(C) water.

(D) all of the above.

2 Uranium is the principal element used in nuclear reactors. One example of a nuclear fission reaction is:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{92}_{36}A + {}_{56}B + 2\,^{1}_{0}n$$

The isotopes A and B respectively are

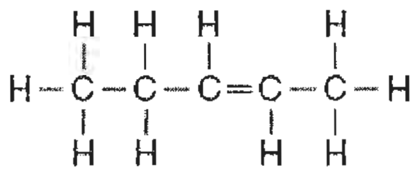
(A) uranium-92 and barium-142.

(B) krypton-36 and barium-56.

(C) krypton-92 and barium-143.

(D) krypton-92 and barium-142.

3 A student was asked to compare the reactions with bromine water of alkanes and alkenes. She decided to use the compound below as one of the two hydrocarbons being investigated.



The other hydrocarbon investigated should be

(A) pent-1-ene.

(B) pentane.

(C) hexane.

(D) cyclohexane.

4 When powdered zinc is warmed with a purple solution containing permanganate ions (MnO_4^-), the solution changes colour due to the formation of almost colourless Mn^{2+}.

During this reaction

(A) manganese has lost electrons and has reached a lower oxidation state.

(B) manganese has gained electrons and has reached a lower oxidation state.

(C) manganese has lost electrons and has reached a higher oxidation state.

(D) manganese has gained electrons and has reached a higher oxidation state.

5 The molar heat of combustion of pentan-1-ol is 2800 kJ mol^{-1}. A quantity of pentan-1-ol was combusted, generating 79.5 kJ of heat energy.

What mass of pentan-1-ol was combusted?

(A) 17.2 g

(B) 2.15 g

(C) 2.50 g

(D) 2.55 g

6 Which of the following metals would you combine with Zinc to produce the highest theoretical voltage under standard conditions for a galvanic cell?

(A) Silver

(B) Iron

(C) Magnesium

(D) Lead

7 Which of the following species has the highest boiling point?

(A) Ethylene

(B) Ethanol

(C) Ethane

(D) Ethanoic acid

8 In the following equation

$HPO_4^{2-}\ (aq) + H_2O\ (l) \rightleftharpoons H_2PO_4^-\ (aq) + OH^-\ (aq)$

(A)	HPO_4^{2-} is acting as an acid	OH^- is acting as its conjugate base
(B)	HPO_4^{2-} is acting as an acid	$H_2PO_4^-$ is acting as its conjugate base
(C)	HPO_4^{2-} is acting as a base	OH^- is acting as its conjugate acid
(D)	HPO_4^{2-} is acting as a base	$H_2PO_4^-$ is acting as its conjugate acid

9 An aqueous solution was tested in the laboratory with various indicators, producing the following results.

Indicator	***Colour***
Phenolphthalein	Colourless
Methyl orange	Yellow
Bromothymol blue	Blue

The solution tested could be

(A) hydrochloric acid.

(B) sodium hydroxide.

(C) seawater.

(D) carbonic acid.

10 Sulfur trioxide is classified as

(A) an acidic oxide, because it reacts with acids to form salts.

(B) a basic oxide, because it produces hydroxide ions in aqueous solution.

(C) an acidic oxide, because it reacts with bases to form salts.

(D) a basic oxide, because it is neutralised by acids.

11 The volume of gas produced when 6.54 g zinc reacts with 50.0 mL of 1.00 mol L^{-1} hydrochloric acid at 0°C and 100 kPa pressure is closest to

(A) 0.568 L

(B) 0.620 L

(C) 2.27 L

(D) 2.48 L

12 What is the pH of the resulting solution when 50.0 mL of 0.15 mol L^{-1} potassium hydroxide solution and 150 mL of 0.10 mol L^{-1} sulfuric acid are mixed?

(A) 0.95

(B) 2.12

(C) 1.4

(D) 1.65

13 A 1.0×10^{-6} mol L^{-1} solution of an acid HX was found to have a pH of 6.00. This solution would best be described as a

(A) concentrated solution of a weak acid.

(B) dilute solution of a strong acid.

(C) dilute solution of a weak acid.

(D) concentrated solution of a strong acid.

14 The pH of a solution of sodium propanoate (CH_3CH_2COONa) was measured to be 8.75.

Which of the following statements best explains the recorded pH?

(A) Sodium ions donate protons to water.

(B) Propanoate ions and sodium ions donate protons to water.

(C) Sodium ions accept protons from water.

(D) Propanoate ions accept protons from water.

15 A student wished to identify the cation and anion present in a colourless aqueous solution. He performed the following tests.

	Test	***Observation***
1	Nitric acid was added to a sample of the solution.	No bubbles of gas formed.
2	Sulfuric acid was added to another sample of the solution.	A white precipitate formed.
3	A flame test was carried out on another sample of the solution.	No distinctive coloured flame was produced.
4	Silver nitrate solution was added to another sample of the solution.	No precipitate formed.
5	Hydrochloric acid was added to another sample of the solution.	A white precipitate formed.

These results are consistent with the presence, in the solution, of

(A) sodium ions and nitrate ions.

(B) sodium ions and chloride ions.

(C) lead (II) ions and nitrate ions.

(D) lead (II) ions and chloride ions.

16 Consider the following reaction at equilibrium:

$$2NO\,(g) + O_2\,(g) \rightleftharpoons 2NO_2\,(g) \qquad \Delta H = -114 \text{ kJ}$$

What would be the effect on the equilibrium of an increase in temperature of the reaction container?

(A) The concentrations of nitrogen monoxide and oxygen will both increase.

(B) The equilibrium will shift to the right.

(C) The concentration of NO_2 *(g)* will increase.

(D) The rate of the reverse reaction will be less than the rate of the forward reaction.

17 Which of the following could be classified as an acid by the Brønsted–Lowry theory, but not by Lavoisier's theory?

(A) CO_2

(B) HBr

(C) H_2SO_4

(D) NH_3

18 Which response matches the systematic and common names of vinyl chloride and styrene?

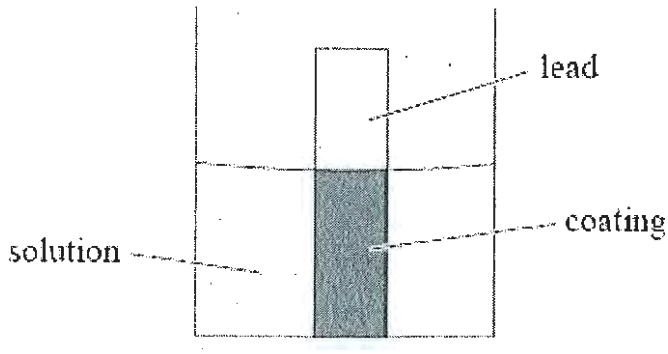
(A) chloroethene ethenyl benzene

(B) polyvinyl chloride polystyrene

(C) vinylidene chloride phenyl ethane

(D) Chloroethene ethyl benzene

19 A student dipped a piece of lead into solution. The lead in contact with the solution became coated with a new substance that was different in appearance to the lead itself.



Which of the following compounds is the solution most likely to contain?

(A) copper(II) nitrate

(B) magnesium nitrate

(C) lead nitrate

(D) zinc nitrate

20 A sample of water from a stream, suspected to be contaminated with metal ions, was analysed. The results of some tests are recorded in the table below.

Test	*Procedure*	*Result*
1	Add dilute $AgNO_3$ solution.	white precipitate formed
2	Add dilute HCl solution.	no change
3	Add dilute Na_2SO_4 solution.	no change
4	Flame test	bright green colour

What is the most likely contaminant in the water?

(A) $BaCl_2$

(B) $CaCO_3$

(C) $CuCO_3$

(D) $CuCl_2$

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2012 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

Student Number

Part B – 80 marks
Attempt Questions 21-33
Allow about 2 hour and 25 minutes for this part

Answer the questions in the spaces provided.

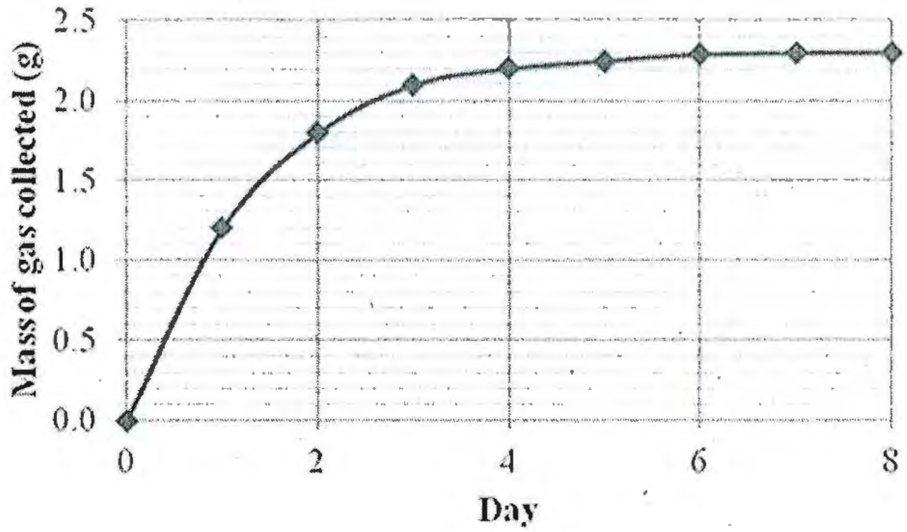
Show all relevant working in questions involving calculations.

Question 21 begins on the next page

Question 21 (4 marks)

A student made a solution by dissolving 5.0 g of glucose in water in a flask and added yeast and a suitable yeast nutrient. The flask was connected via a delivery tube to a syringe. The syringe was weighed at regular intervals over an 8-day period in order to calculate the mass of gas which had been collected in the syringe.

The graph shows the mass of gas collected over the 8-day period. The reaction was conducted at 25°C and 100 kPa.



(a) Identify the gas produced. **1**

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(b) Calculate the volume of gas which would have been in the syringe. **1**

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(c) Calculate the mass of glucose which had fermented during the 8-day period. **2**

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Question 22 (6 marks)

During your study of oxidation-reduction reactions, you have carried out an investigation of the chemistry and structure EITHER of a dry cell OR a lead-acid cell.

(a) Identify which cell you have investigated. **1**

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(b) Draw a labelled diagram to show the structure of the cell. Ensure that you have identified the anode, cathode and electrolyte. **2**

(c) Write half-equations for the half-cell reactions. **2**

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(d) Identify ONE benefit and ONE problem associated with the use of this cell. **1**

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Question 23 (5 marks)

All Lowry-Bronsted acid-base reactions involve the formation of a co-ordinate covalent bond.

(a) Define acids and bases according to the Lowry-Bronsted theory. **1**

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(b) The hydronium ion (H_3O^+) acts as an acid in aqueous solution. By using electron-dot formulae for the reactants and the products, show the formation of a co-ordinate covalent bond when hydronium ion reacts with ammonia (NH_3). **2**

(c) Explain what is meant by a co-ordinate covalent bond. Indicate, on your equation in part (b) above, the bond formed during the reaction which is classified as a co-ordinate covalent bond. **2**

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Question 24 (6 marks)

A manufacturer made a lemon drink by mixing flavouring, sugar syrup and citric acid.

A chemist determined the concentration of the citric acid by titration with NaOH.

The sodium hydroxide solution was prepared by dissolving 4.176 g of NaOH pellets in water to give 1.000 L of solution. This solution was standardised by titrating 25.00 mL with a 0.1024 mol L^{-1} standardised solution of HCl. The average titration volume was found to be 25.10 mL.

To analyse the citric acid concentration, 50.00 mL of the lemon drink was diluted to 500.0 mL. 25.00 mL of the diluted solution was then titrated with the NaOH solution to the phenolphthalein endpoint.

The following data were collected during the titration of the diluted lemon drink with the standardised sodium hydroxide solution.

Titration 1	28.30 mL
Titration 2	27.50 mL
Titration 3	27.45 mL
Titration 4	27.55 mL

(a) Why was the concentration of the standardised NaOH solution (as calculated using the titration data) different from the concentration of NaOH as calculated using the mass of pellets dissolved? Assume that no human error occurred. **2**

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Question 24 continues on the next page

Question 24 (continued)

(b) Calculate the concentration of the citric acid in the manufactured lemon drink. 4

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Question 25 (6 marks)

Carbon dioxide is an acidic oxide and the acid it forms is classified as weak.

(a) Write an equation to show the formation of an acid from the reaction of carbon dioxide gas with water. Show correct states in your equation, assuming the reaction occurs at 25°C. **1**

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(b) Explain why a solution of sodium hydrogen carbonate has a pH greater than 7. Use an equation in your response. **2**

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(c) Outline a procedure you used to determine the moles of CO_2 evolved during the decarbonation of a soft drink. **3**

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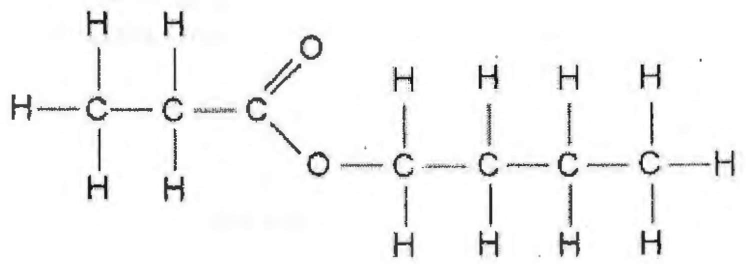
Question 26 (8 marks)

The compound shown below was prepared in a school laboratory by refluxing TWO carbon compounds with concentrated sulfuric acid.



(a) Draw the expanded structural formulae for the TWO carbon compounds and name these compounds. **2**

(b) Explain the roles of sulfuric acid in the formation of this compound. **2**

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Question 26 continues on the next page

Question 26 (continued)

(c) Provide a risk assessment of this procedure and outline the steps taken to reduce these risks. **4**

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Question 27 (9 marks)

(a) Write a balanced equation for the reaction to form ammonia during the Haber process, showing the energy term in your equation. **1**

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(b) Explain why the yield of ammonia is reduced at high temperatures. **1**

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(c) Identify a catalyst used for the Haber process. **1**

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(d) Discuss the need for the monitoring by chemists of the catalyst AND of the temperature of the reaction vessel during the Haber process. **3**

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Question 27 continues on the next page

Question 27 (continued)

(e) Evaluate the impact the development of the Haber process had on world history. **3**

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Question 28 (8 marks)

A scientist monitoring the impact of effluent on a river system used AAS to compare the lead ion concentration above and below the effluent discharge point in the river.

The table below shows the absorbance values for the water samples and also those for a range of standard solutions.

Solution	*$[Pb^{2+}]$ (mg/L)*	*Absorbance %*
Standard	0.1	15
Standard	0.2	32
Standard	0.4	63
Standard	0.6	97
River sample 1		1
River sample 2		2
River sample 3		53
River sample 4		48

(a) Use the grid below to plot the absorbance for the standards. **2**

(b) Complete the data in the table for the $[Pb^{2+}]$. **2**

Question 28 continues on the next page

Question 28 (continued)

(c) Assess the quality of the river water for freshwater organisms, above and below the entry point of the effluent, given that the maximum acceptable level for $[Pb^{2+}]$ is 0.05 ppm. **1**

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(d) Outline a chemical procedure for determining the lead ion concentration in a river. Include an equation for the reaction(s) you describe. **3**

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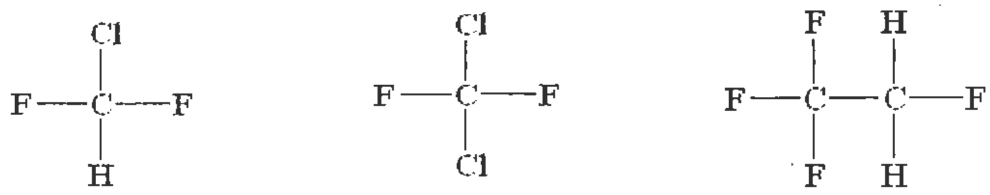
Question 29 (7 marks)

The structural formulae of three haloalkanes are shown below.



Compound 1 *Compound 2* *Compound 3*

(a) Give the correct systematic (IUPAC) name for ***All 3 compounds*** **3**

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(b) Using Compounds 1 2 and 3 above, evaluate the impacts of the above haloalkane compounds on depletion of ozone in the stratosphere. Include an equation for the depletion of ozone in your response. **4**

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Question 30 (4 marks)

Ozone and oxygen gas are allotropes, with different chemical and physical properties.

(a) In the spaces below, draw an electron dot diagram of oxygen gas, and ozone. Label and name all the bond types in ozone. **2**

Oxygen gas	Ozone

(b) Describe one physical property and explain the difference between Oxygen gas and Ozone. **2**

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Question 31 (5 marks)

Heavy metal ions are continuously monitored in the waterways of countries all over the world.

Justify reasons for monitoring these ions, and discuss a technology used to identify their presence and measure their concentration.

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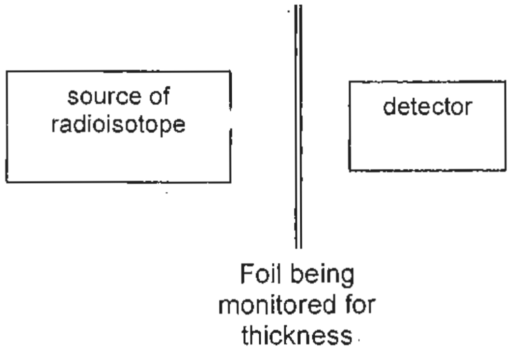
Question 32 (6 marks)

The following information describes the industrial use of radioisotopes to gauge the thickness of thin films, such a thin metal foils.

The radiation emitted from a radioisotope has its intensity reduced by matter placed between the radioactive source and a detector. The detector measures this reduction and thus can be used to measure the thickness of material between the source and the detector. This is shown in the simplified diagram to the right,



(a) Identify an instrument that may be used to detect the radiation produced by the radioisotope. **1**

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(b) The table below shows three examples of radioisotopes (A, B and C) and the type of radiation that each emits. **2**

Radioisotope	Type of radiation it emits
A	alpha only
B	beta only
C	gamma only

On the basis of the information in the table, assess the suitability of each radioisotope for use as a thickness gauge in the production of foil.

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Question 32 continues on the next page

Question 32 (continued)

(c) Name an isotope used in medicine **1**

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(d) Describe a method of producing radioisotopes **2**

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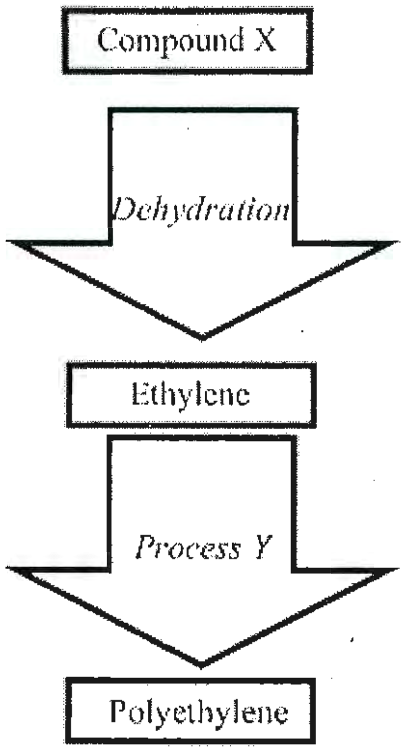
Question 33 (6 marks)

The flow chart shows the production of polyethylene.



(a) Identify Compound X **1**

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(b) Identify and describe process Y. **4**

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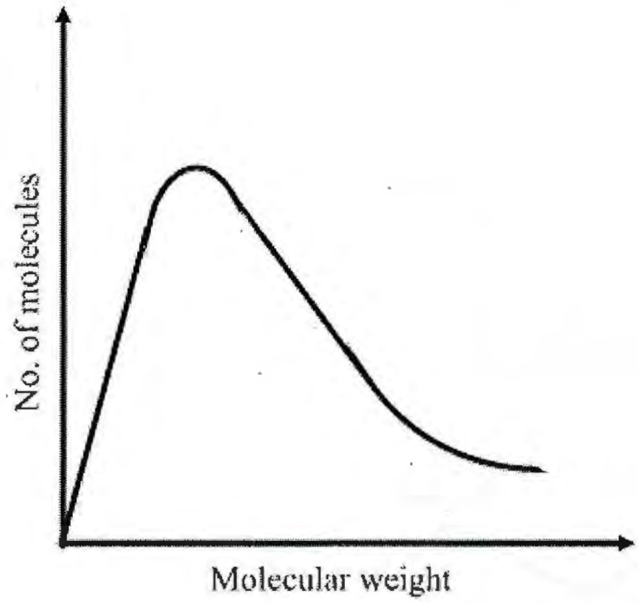
Question 33 continues on the next page

Question 33 (continued)

A sample of polyethylene was produced by process Y. The following graph shows the distribution of molecules by molecular weights of polymer molecules in the sample



(c) Why is a range of molecular weights observed? **1**

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END OF EXAMINATION

DATA SHEET

Avogadro constant, N_A .... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and
at 0°C (273.15 K) .... 22.71 L
at 25°C (298.15 K) .... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w .... 1.0×10^{-14}

Specific heat capacity of water .... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$pH = -\log_{10}[H^+]$ $\qquad$ $\Delta H = -mC\Delta T$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium						

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Elements with atomic numbers 113 and above have been reported but not fully authenticated.

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of data. Some data may have been modified.