The Production of Materials
&
The Acidic Environment

Mid-Year Exam T1 2012

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 1.5 hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A Data Sheet and a Periodic Table are provided at the back of this paper
- Write your Student Number at the top of pages to be marked.
- No extra paper/booklets are required in addition to the written examination booklet

86 marks

This section has two parts, Part A and Part B

Part A - 20 marks
- Attempt Questions 1 - 20

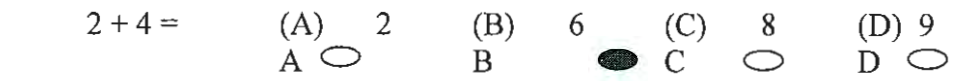
Part B – 66 marks
- Attempt Questions 21 - 33

Part A – 20 marks
Attempt Questions 1 - 20

Use the multiple-choice answer sheet.

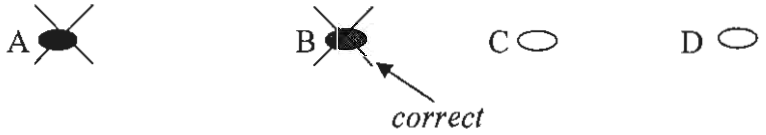
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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



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

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



Student Number: _____

PART A (10 MARKS) MULTIPLE CHOICE ANSWER SHEET

SHADE IN PENCIL the best response in the grid below.

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

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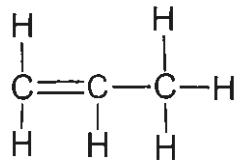
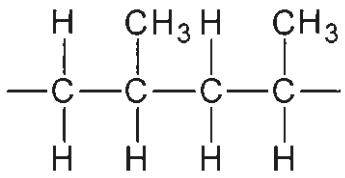
1. The diagram shows the structure of a small molecule, which undergoes polymerisation.

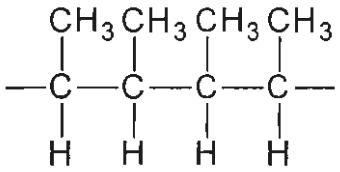


Which structure below best represents a portion of the polymer chain formed from the polymerisation?

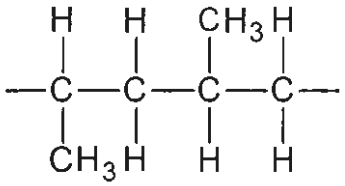
(A)



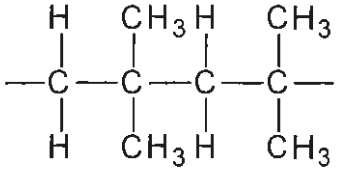
(B)



(C)



(D)



2. A radioisotope undergoes 2 alpha decays, followed by a beta decay, forming actinium-230 as a result.

Which of the following is the original radioisotope?

(A) plutonium-244

(B) uranium-238

(C) thorium-232

(D) neptunium-237

3. A student is required to prepare some 0.100 M HCl from 1.00 M HCl.

What apparatus do they need to do this?

(A) pipette and burette

(B) burette and measuring cylinder

(C) pipette and volumetric flask

(D) measuring cylinder and volumetric flask

4. A 0.045M solution of HCl has a pH of 1.35. A student takes 10 mL of this solution and dilutes it to 1 L. What is the pH of the diluted solution?

(A) 0.35

(B) 1.35

(C) 2.35

(D) 3.35

5. The molar heats of combustion of ethanol, 1-propanol and 1-butanol are 1367 kJ mol^{-1}, 2010 kJ mol^{-1} and 2882 kJ mol^{-1} respectively.

Which of the following best explains this trend in molar heats of combustion of the alkanols as the length of the carbon chain increases?

(A) The dispersion forces increase.

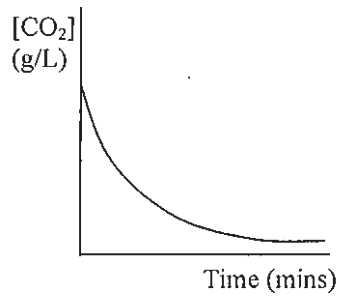
(B) More covalent bonds need to be broken.

(C) The polarity increases.

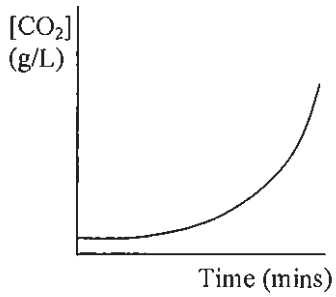
(D) More moles of carbon dioxide and water are formed.

6. A sports player buys a bottle of soft drink from a shop on her way to a match. She drinks a small amount, and leaves the lid off the bottle while playing.

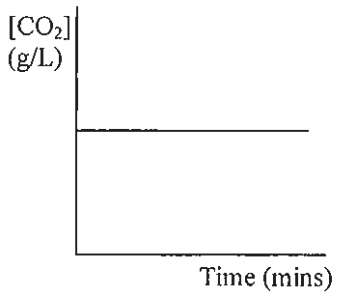
Which of the following graphs represents the concentration of dissolved CO_2 in the bottle over time?



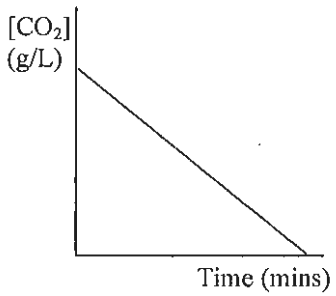
(A)



(B)



(C)



(D)

7 A table of redox couples and their standard potentials is shown.

Redox couple	E^o
Ag^+/Ag	0.80 V
Ni^{2+}/Ni	-0.24 V
Pd^{2+}/Pd	0.92 V
Fe^{2+}/Fe	-0.44 V

Which of the following ranks the metals in decreasing order of their electrochemical activity?

(A) Ni > Fe > Ag > Pd

(B) Fe > Ni > Ag > Pd

(C) Pd > Ag > Ni > Fe

(D) Ni > Fe > Pd > Ag

8 Which of the following can be described as a monomer of a natural biopolymer?

(A) Cellulose

(B) Ethylene

(C) Glucose

(D) Ethane

9 An isotope is required to be injected into a patient suspected of suffering from cancer of the bones. What would be a suitable half-life for the chosen isotope?

(A) 8 days and emit alpha particles.

(B) 5 years and emit gamma rays.

(C) 8 days and emit gamma rays.

(D) 5 hours and emit gamma rays.

10 All of the carbon dioxide in a soft drink of initial mass 356.05 g was carefully extracted and collected as a gas. The final mass of the drink was 355.42 g.

What volume would the carbon dioxide occupy at 100 kPa and 25°C?

(A) 0.33 L

(B) 0.35 L

(C) 0.56 L

(D) 0.63 L

11 When carbon dioxide dissolves in water, heat is released.

$CO_2\ (g) \rightleftharpoons CO_2\ (aq)$

When carbon dioxide reacts with water, hydronium ions and hydrogen carbonate ions are formed.

$CO_2\ (aq) + 2H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + HCO_3^-\ (aq)$

The solubility of carbon dioxide in water can be increased by

(A) increasing the pressure.

(B) decreasing the temperature.

(C) making the water slightly alkaline.

(D) all of the above.

12 Consider the following reaction at equilibrium:

$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g) \quad \Delta H = -92\ kJ\ mol^{-1}$

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

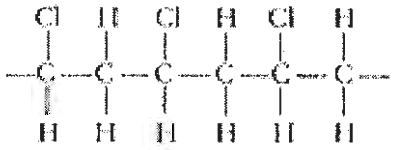
(A) The concentrations of nitrogen and hydrogen will both increase.

(B) The equilibrium will shift to the right.

(C) The concentration of $NH_3(g)$ will increase.

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

13 What are the preferred and systematic names for the monomer used in the formation of the polymer represented below?



	Preferred name	Systematic name
(A)	Chloroethane	Vinyl chloride
(B)	Vinyl chloride	Chloroethane
(C)	Vinyl chloride	Chloroethene
(D)	Chloroethene	Vinyl chloride

14 In which of the following changes does the metal atom show the greatest decrease in oxidation state?

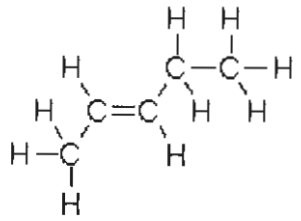
(A) CuO to Cu_2O

(B) $Cr_2O_7^{2-}$ to Cr^{3+}

(C) Mg to MgO

(D) Fe^{2+} to Fe^{3+}

15 Bromine water is added to the hydrocarbon represented below.



The product formed is

(A) 3-bromopentane

(B) 1,2-dibromopentene

(C) 3,4-dibromopentane

(D) 2,3-dibromopentane

16 During an experiment to monitor the fermentation of glucose, 1.6 g of glucose was completely converted to ethanol and carbon dioxide.

What mass of carbon dioxide was produced?

(A) 0.31 g

(B) 0.78 g

(C) 1.6 g

(D) 2.4 g

17 Ethanoic acid and ethanoate ions form an equilibrium as shown below.

$CH_3COOH\ (aq) + H_2O\ (l) \rightleftharpoons CH_3COO^-\ (aq) + H_3O^+\ (aq)$

Which solution would increase the concentration of the ethanoate ions when added to the equilibrium mixture?

(A) Sodium chloride

(B) Hydrochloric acid

(C) Sodium hydroxide

(D) Sodium nitrate

18 Phosphorus pentoxide 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.

19 The conjugate acid of the molecule NH_3 is

(A) NH_3^-

(B) NH_2^-

(C) NH_4^+

(D) NH_4

20 A 1.0×10^{-5} mol L^{-1} solution of an acid HX was found to have a pH of 5.00. 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.

End of part A

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Student Number:_____

Chemistry

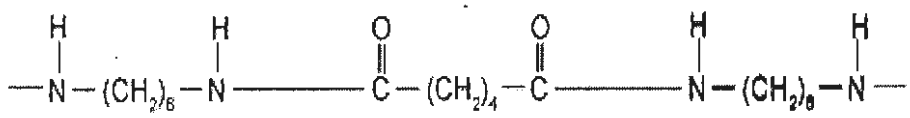
Part B – 66 marks
Attempt Questions 21 - 33

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 21 (5marks)

Marks

The structure below shows one example of a polymer classified as a type of nylon.



(a) Draw structural formulae of the monomers which produced the nylon polymer shown above. **2**

(b) Identify the other product formed when the monomers in (a) react to form the polymer. **1**

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(c) Describe key differences between the type of reaction which would produce the nylon polymer shown, and the type which would produce polyethylene. **2**

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Student Number:_____

Question 22 (5 marks)

Marks

On the 11th of March 2011, a tsunami off the coast of Japan resulted in a significant accident at the Fukushima Nuclear facility.

In the days following the accident, levels of radioactive iodine-131 and caesium-137 have increased in the atmosphere and rain water collected around the facility.

(a) Identify one instrument which could be used to detect the presence of radioactive materials on the clothing of a clean-up worker after the accident. **1**

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(b) Evaluate the need for careful monitoring of levels of radioactivity in extended areas around the facility for a long period of time following this accident. **4**

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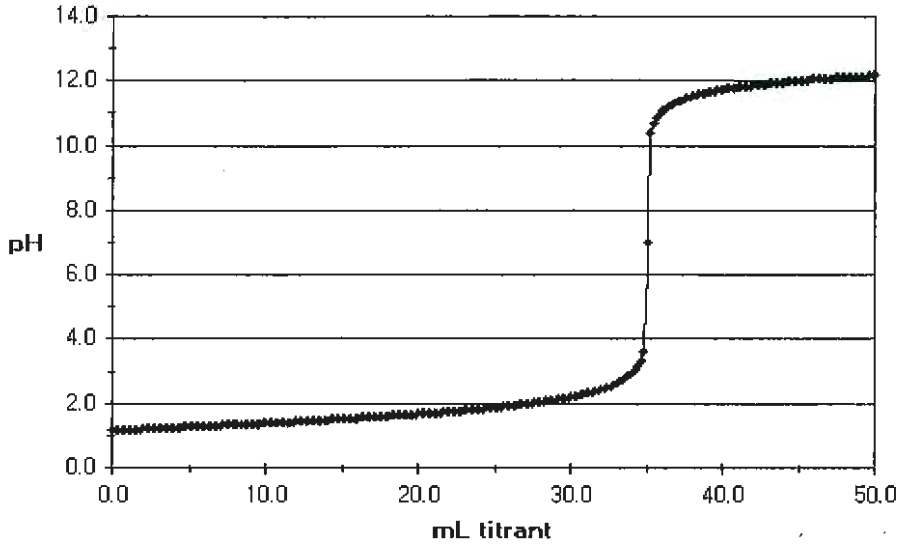
Student Number:_____

Question 23 (5 marks)

Marks

In order to calculate the concentration of a sample of HCl, a student titrated a 25.0 mL sample of the acid against 0.075 M $Ca(OH)_2$ (the titrant).

She used a pH probe connected to a data logger to monitor the reaction, and her results are shown in the graph below.



(a) Write a balanced chemical equation for the reaction that occurs during the titration. **1**

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(b) Use the graph to calculate the concentration of the hydrochloric acid. **2**

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(c) Outline another method the student could have used to estimate the equivalence point of the titration, identifying any specific chemical required and observations made. **2**

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Student Number:_____

Question 24 (9 marks)

Marks

Polyethylene is manufactured in two forms, HDPE and LDPE.

(a) Using appropriate diagrams or equations, outline the steps in the manufacture of ONE of these forms from its monomer, ethylene. **3**

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(b) Use a table to compare the structures, properties and uses of the TWO forms of polyethylene. **6**

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Student Number:_____

Question 25 (3 marks) **Marks**

The table shows properties of octane and ethanol.

Fuel	*Heat of combustion (kJ g^{-1})*	*Boiling point*
Octane	47.9	125.7
Ethanol	29.7	78.3

(a) Which of octane and ethanol releases more energy per mole when burnt completely in oxygen? Show your working or reasoning. **2**

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(b) Write a balanced equation for the complete combustion of 1 mole of ethanol. Include the ΔH value. **1**

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Student Number:_____

Question 26 (5 marks) **Marks**

The hydrogen carbonate ion (HCO_3^-) and carbonate ion (CO_3^{2-}), when mixed in appropriate concentrations, form a buffer solution.

(a) Explain, using an appropriate equation (either the carbonate ion or the hydrogen carbonate ion), why aqueous solutions of sodium hydrogen carbonate and sodium carbonate both have pH values greater than 7. **2**

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(b) Use the mixture of hydrogen carbonate ion (HCO_3^-) and carbonate ion (CO_3^{2-}), to explain the properties of a buffer solution. **3**

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Student Number:_____

Question 27 (8 marks) **Marks**

Fermentation of sugars is necessary to convert most natural polymers to useful liquid energy sources.

(a) Write a balanced equation for the fermentation of glucose. **1**

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(b) Identify the optimum conditions for carrying out this fermentation reaction. **2**

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(c) "The inefficiency of the fermentation process limits the viability of carbohydrates as sources of other chemicals. However, carbohydrates are becoming increasingly important as sources of carbon." **5**

Justify the increasing use of carbohydrates as sources of energy.

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Student Number:_____

Question 28 (7 marks) **Marks**

(a) Write a nett ionic equation for the reaction of hydrochloric and potassium hydroxide solutions. **1**

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(b) A solution of 0.00001 mol L^{-1} hydrochloric acid is classified as a dilute, strong acid. Explain this classification. **2**

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(c) Acetic acid is a monoprotic weak acid. Draw the structural formula for acetic acid and explain why it is classified as a monoprotic weak acid. **2**

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(d) Calculate the mass of sodium acetate formed when 5.0 g acetic acid is added to 100.0 mL of 0.50 mol L^{-1} sodium hydroxide solution. Show all working. **2**

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Student Number:_____

Question 29 (3 marks)

Marks

Sodium oxide and sulfur dioxide are classified as basic and acidic oxides respectively.

(a) Write an equation for the reaction of sodium oxide with water and explain why sodium oxide is classified as basic. **2**

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(b) A solution of sulfur dioxide was found to have a hydrogen ion concentration of 6.12×10^{-4} mol L^{-1}. Calculate the pH of this solution. **1**

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Student Number:_____

Question 30 (3 marks)

Marks

Titration is an important analytical technique. Sodium hydrogen carbonate ($NaHCO_3$) can be used as a primary standard in titrations.

(a) Calculate the concentration of a solution of sodium hydrogen carbonate if 1.053 g of the solid is dissolved completely in de-ionised water to form 100.0 mL of solution. **1**

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(b) Determine the concentration of a solution of hydrochloric acid if 18.7 mL of the hydrochloric acid reacts completely with 10.0 mL of this standard sodium hydrogen carbonate solution. **2**

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Student Number:_____

Question 31 (4 marks)

Marks

The dihydrogen phosphate ion ($H_2PO_4^-$) is amphiprotic and a solution of the salt sodium dihydrogen phosphate in water has a pH close to 5.

(a) Explain why the dihydrogen phosphate ion is described as amphiprotic. Include TWO appropriate equations in your response. **2**

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(b) Explain why a solution of the salt sodium dihydrogen phosphate in water has a pH close to 5. Include an equation in your response. **2**

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Student Number:_____

Question 32 (3 marks) **Marks**

Draw up a table to compare the chemistry and uses of TWO commercial electrochemical cells you have studied. Include equations for the half-cell reactions you describe. **3**

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Student Number:_____

Question 33 (6 marks)

Draw a detailed diagram of a galvanic cell for: $Ag^+ \mid Ag \mid\mid Pb \mid Pb^{2+}$ **4**

(a) List TWO observations (apart from the voltage reading) that you would make after the cell had been operating for 20 minutes. **1**

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(b) Calculate the EMF of the cell. **1**

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END OF TEST

Student Number:_____

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

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

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 of element
Atomic Weight — 197.0 — Name of element
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 65.41 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 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] 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 Cesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 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 [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223] Francium	88 Ra [226] Radium	89–103 Actinoids	104 Rf [261] Rutherfordium	105 Db [262] Dubnium	106 Sg [266] Seaborgium	107 Bh [264] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [145] 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 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac [227] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (October 2005 version) is the principal source of data. Some data may have been modified.

Student Number: