Saint Ignatius' College
RIVERVIEW

Student Number

St Ignatius' College Riverview - Faculty of Science

2022 HSC Assessment Task #4

CHEMISTRY

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approvxed by NESA may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this paper

Total Marks 100

SECTION I – 20 marks (pages 2–8)

- Attempt Questions 1– 20
- Allow about 35 minutes for this section

SECTION II – 80 marks (pages 9–26)

- Attempt Questions 21– 34
- Allow about 2 hours and 25 minutes for this section

SECTION I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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1 ‘An acid is a substance that donates one or more protons.’
This definition of an acid was first given by

A. Arrhenius.
B. Brønsted–Lowry.
C. Lewis.
D. Lavoisier.

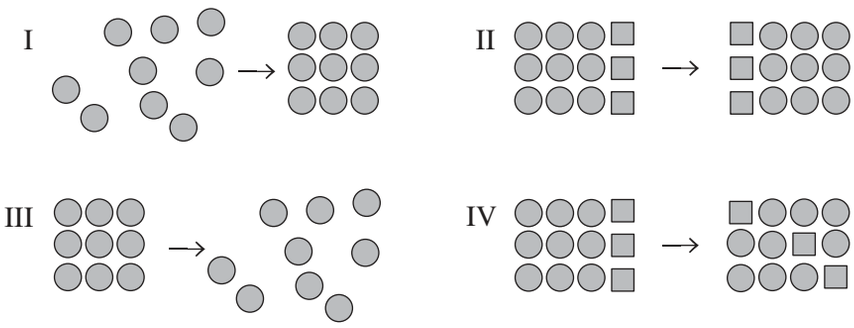
2 Which of the following substances would make the best primary standard?

	Substance	*Purity*	*Solubility*	*Formula mass*
A.	P	high	low	low
B.	Q	high	high	high
C.	R	high	low	high
D.	S	high	high	low

3 Which of the following compounds has the highest molar solubility in water at 25°C?

A. $BaCO_3$
B. $Mg_3(PO_4)_2$
C. $Pb(OH)_2$
D. $CaSO_4$

4 The diagram shows four different systems.



Which systems show an increase in entropy?

A. I and II only

B. II and III only

C. III and IV only

D. I and IV only

5 Cloudy ammonia is an ingredient of some household cleaners. It forms an equilibrium mixture when dissolved in water, as shown in the equation.

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

Which of the following is the equilibrium expression for the reaction from right to left?

A. $\dfrac{[NH_4^+][OH^-]}{[NH_3]}$

B. $\dfrac{[NH_4]}{[NH_3^+][OH^-]}$

C. $\dfrac{[NH_3][OH^-]}{[NH_4^+]}$

D. $\dfrac{[NH_3]}{[NH_4^+][OH^-]}$

6 Four different equilibrium systems (I–IV) at standard pressure and temperature are shown.

I	$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	$\Delta H < 0$
II	$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$	$\Delta H < 0$
III	$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$	$\Delta H > 0$
IV	$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$	$\Delta H > 0$

In each system, the pressure was increased. Later, the temperature was decreased.

In which equilibrium system would BOTH changes result in a product yield increase?

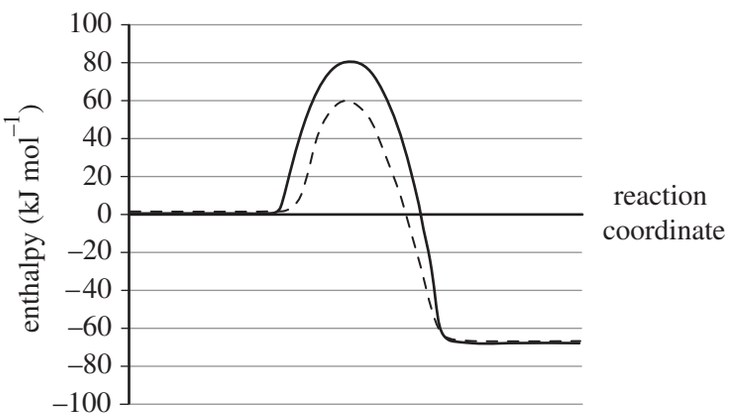
A. I

B. II

C. III

D. IV

7 A particular reaction can occur with or without a catalyst. The energy profiles of this reaction, both catalysed and uncatalysed, are shown.



Which row of the table best matches the reactions as shown by the energy profiles?

	E_a *of uncatalysed reaction (kJ mol^{-1})*	ΔH *of uncatalysed reaction (kJ mol^{-1})*	E_a *of catalysed reaction (kJ mol^{-1})*	ΔH *of catalysed reaction (kJ mol^{-1})*
A.	–80	70	–60	70
B.	80	–150	80	60
C.	80	–70	60	–70
D.	20	80	150	–80

8 Stomach (gastric) acid is a solution of mainly hydrochloric acid and can vary between 0.01 mol L^{-1} and 0.1 mol L^{-1}. Sometimes, excess acid is secreted in the stomach. Medications can be taken to neutralise the surplus acid.

Which of the following substances would be best suited to safely neutralising this acid?

A. a dilute solution of sodium chloride

B. a dilute suspension of sodium hydrogen carbonate

C. a concentrated solution of sodium hydroxide

D. large quantities of distilled water

9 Citric acid has the formula $H_3C_6H_5O_7$. It is often used as a flavouring and preservative in food and drinks. A solution of citric acid is neutralised by a solution of sodium hydroxide.

Which of the following equations correctly represents this reaction?

A. $3NaOH(s) + H_3C_6H_5O_7(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3H_2O(l)$

B. $3NaOH(aq) + H_3C_6H_5O_7(aq) \rightarrow 3NaC_6H_5O_7(aq) + 3H_2O(l)$

C. $NaOH(aq) + 3H_3C_6H_5O_7(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3H_2O(l)$

D. $3NaOH(aq) + H_3C_6H_5O_7(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3H_2O(l)$

10 Phosphoric acid (H_3PO_4) is a triprotic acid. It dissociates in water in three stages as shown.

Stage 1: $H_3PO_4(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + H_2PO_4^-(aq) \qquad K_{a1} = 7.3 \times 10^{-3}$

Stage 2: $H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HPO_4^{2-}(aq) \qquad K_{a2} = 6.3 \times 10^{-8}$

Stage 3: $HPO_4^{2-}(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HPO_4^{3-}(aq) \qquad K_{a3} = 4 \times 10^{-13}$

A student wants to calculate the approximate pH of a 0.1 mol L^{-1} solution of phosphoric acid.

Which value(s) of the dissociation constants should the student use?

A. K_{a1} only

B. K_{a3} only

C. $K_{a1} - K_{a2} - K_{a3}$

D. $K_{a1} \times K_{a2} \times K_{a3}$

11 Which of the following compounds forms a 0.00100 mol L^{-1} aqueous solution with a pH closest to 7.00?

A. sodium ethanoate

B. ethanol

C. ethanamine

D. 2,3-dihydroxypropanoic acid

12 Which of the following is a functional group isomer of pentan-2-one?

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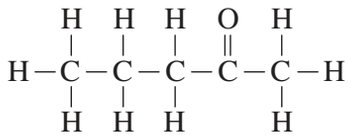
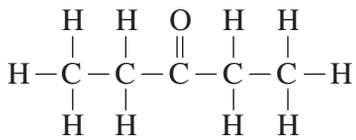


B.


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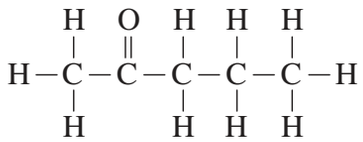
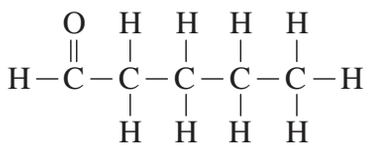
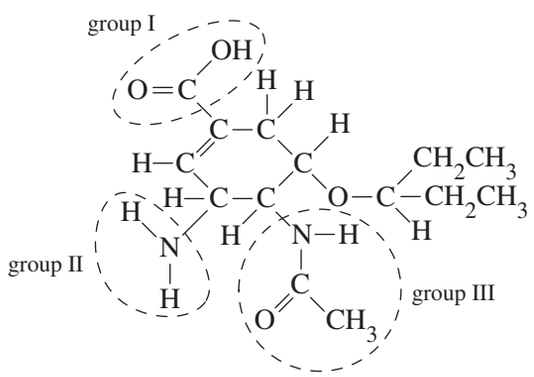


D.


13 The structure of a compound is shown. It has been suggested that this molecule may be an effective drug for treating seasonal influenza (the flu).



Which row of the table correctly names the functional groups labelled I, II and III?

	Group I	*Group II*	*Group III*
A.	amide	amine	ester
B.	carboxylic acid	amine	amide
C.	ketone	amine	carboxylic acid
D.	alcohol	amide	amine

14 A student performed an experiment in which 250 mL of water was heated by burning methanol in a spirit burner. The enthalpy of combustion of methanol is –726 kJ mol^{-1}. Assume that all heat released by the process is absorbed by the water.

What is the maximum change in temperature of the water when 1.26 g of methanol is completely combusted?

A. 0.434°C

B. 3.66°C

C. 27.3°C

D. 36.3°C

15 An experiment is conducted in which 4-aminobutanoic acid, $H_2N(CH_2)_3COOH$, forms a condensation polymer. One mole of it contains 1000 monomer units.

What is the mass of this polymer?

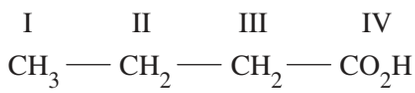
A. 8.5×10^4 g mol^{-1}

B. 1.0×10^5 g mol^{-1}

C. 1.0×10^3 g mol^{-1}

D. 9.7 g mol^{-1}

16 The structure of a compound is shown. Its carbon atoms are labelled I–IV.



Which carbon atom has a trigonal planar arrangement of bonds around it?

A. I

B. II

C. III

D. IV

17 A table of reactions involving organic compounds is shown.

Reaction	*Product*
but-2-ene + hydrogen bromide	1
butanal + acidified potassium dichromate	2
butan-2-ol + ethanoic acid + catalyst	3
butanoic acid + sodium hydrogen carbonate	4

Which row of the table correctly identifies a product from each reaction?

	Product 1	*Product 2*	*Product 3*	*Product 4*
A.	2-bromobutane	butanoic acid	2-butyl ethanoate	sodium butanoate
B.	2-bromobutane	sodium butanoate	butanoic acid	carbon dioxide
C.	butane	butanoic acid	2-butyl ethanoate	carbon dioxide
D.	2-bromobutane	2-butyl ethanoate	butanoic acid	sodium butanoate

18 Which of the following statements best explains the cleaning action of soap?

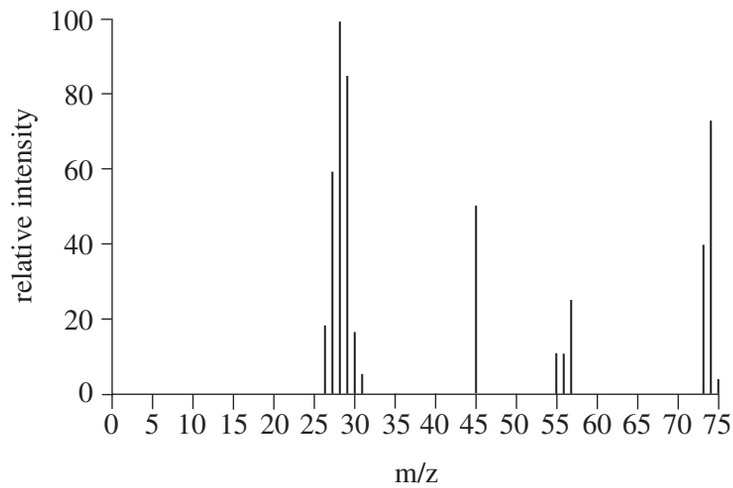
A. The polar head group forms dispersion forces with oils and fats and the non-polar tail group forms hydrogen bonds with water.

B. The non-polar tail group forms dispersion forces with oil and fats, as well as forming dipole–dipole forces with water.

C. The polar head group forms dipole–dipole forces with oil, fats and water.

D. The polar head group forms ion–dipole forces with water and the non-polar tail group forms dispersion forces with oil and fats.

19 The diagram shows a simplified mass spectrum of propanoic acid.



What does the peak at m/z = 45 represent?

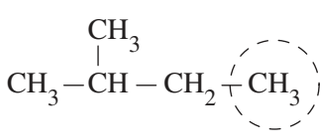
A. $[CH_3CH_2CO]^+$

B. $[CH_3COH_2]^+$

C. $[CO_2H]^+$

D. the base peak for the mass spectrum

20 The structure of 2-methylbutane is shown. A CH_3 group is circled



Which of the following splitting patterns would be observed in the ^1H NMR spectrum for the CH_3 group circled?

A. 

B. 

C. 

D. 

Student Number

HSC Year 12 Chemistry

Section II Answer Booklet

80 marks
Attempt Questions 21–34
Allow about 2 hours and 25 minutes for this section

Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided on pages at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (4 marks)

Draw a table that compares THREE characteristics of static and dynamic equilibrium systems. **4**

Question 22 (7 marks)

Many reactions involving ionic compounds will only take place when the ionic compounds are in aqueous solutions.

(a) Describe the processes involved in the dissolution of ionic compounds in water. **4**

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(b) Equimolar aqueous solutions of silver nitrate and magnesium chloride are mixed at 25°C. **3**
Write the overall equation AND net ionic equation for any reactions that occur.

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Question 23 (9 marks)

Carbonyl chloride ($COCl_2$) gas can be formed in an equilibrium reaction between carbon monoxide (CO) gas and chlorine (Cl_2) gas. A 10 L vessel containing these gases under standard conditions, but not at equilibrium, was sampled. It was found that there were 0.11 moles of carbon monoxide, 0.63 moles of chlorine and 2.9 moles of carbonyl chloride present in the vessel. The equilibrium constant (K_{eq}) for this reaction, under the conditions used, is 2.62×10^2 mol L^{-1}.

(a) Write the equilibrium expression for this reaction. **1**

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(b) After sampling, in which direction will the reaction shift in order to reach equilibrium? Justify your answer. **4**

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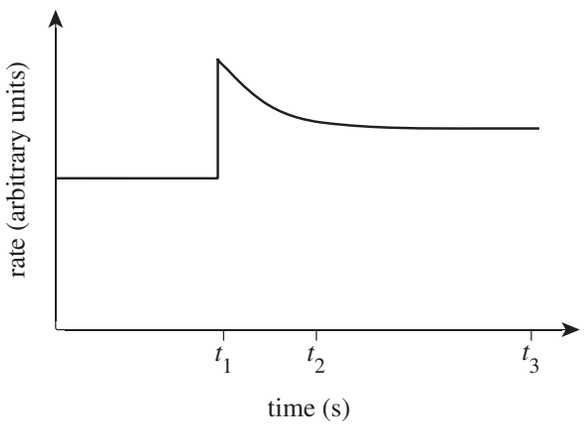
Question 23 continues on page 12

Question 23 (continued)

(c) The mixture of carbon monoxide, chlorine and carbonyl chloride was allowed to come to equilibrium. The rate of reaction was monitored at a constant temperature. The diagram shows the rate of formation of carbonyl chloride over a period of time. At t_1, the volume of the reaction vessel was decreased. **4**



Explain, using collision theory, the shape of the graph over time. Refer to any factors that affect the rate of the reaction in your answer.

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End of Question 23

Question 24 (7 marks)

A buffer solution is prepared from 1.00 L of 0.0500 M CH3COOH (Ka = 1.8 x 10–5) and 2.50 g sodium acetate, NaCH3COO. **7**

(a) What is the pH of this solution? (4)

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(b) 1.00 mL of a 1.00 M solution of hydrochloric acid is added to the buffer. (3)

Write an equation for the major reaction that takes place.

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Would the pH of the solution after addition of the hydrochloric acid be

I – slightly above that calculated in part (a)
II – equal to that calculated in part (a)
III – slightly below that calculated in part (a)?

Explain your reasoning. (No calculations are required.)

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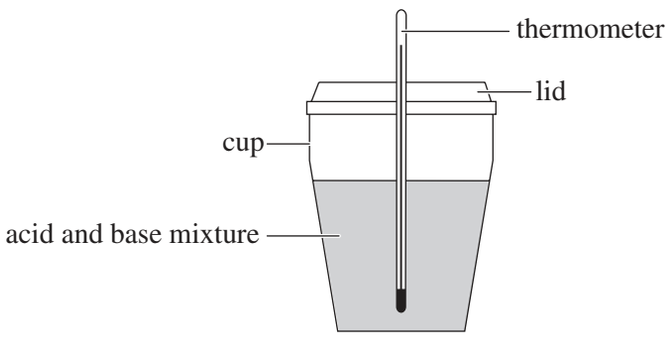
Question 25 (9 marks)

A class carried out an experiment to find the molar enthalpy of neutralisation of the reaction between a solution of sodium hydroxide and a dilute solution of nitric acid. The students were provided with the relevant glassware, a calorimeter and standardised aqueous solutions of sodium hydroxide (2.4 mol L^{-1}) and nitric acid (2.1 mol L^{-1}). The calorimeter provided is shown in the diagram.



The students were asked to calculate the amount of nitric acid required to neutralise 50 mL of the sodium hydroxide solution. The students split into groups. Each group noted the initial temperature of the solution, added the calculated amount of sodium hydroxide to 50 ml of the acid, stirred the mixture and then recorded the change in temperature. An average of the temperatures was obtained and used in later calculations. The results are shown in the table.

Group	*Temperature change (°C)*
A	+9
B	+9
C	+10
D	+9
E	+10

(a) What material should be used for the cup of the calorimeter in the experiment? Justify your answer. **1**

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(b) Calculate the initial pH of the sodium hydroxide solution. Show all relevant working. **2**

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Question 25 continues on page 15

Question 25 (continued)

(c) Calculate the exact volume of nitric acid needed to neutralise the sodium hydroxide solution. Show all relevant working. **2**

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(d) Calculate the molar enthalpy of neutralisation for this reaction. Show all relevant working. **3**

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(e) The accepted value for the molar enthalpy of neutralisation in this reaction is 57.3103 J. **1**

Compare this to the value calculated in part (d) and suggest a reason for any discrepancy between the two values.

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End of Question 25

Question 26 (4 marks)

Some salts display amphiprotic behaviour. **4**

Using a suitable example, explain what is meant by 'amphiprotic'. Support your answer with at least ONE chemical equation.

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Question 27 (4 marks)

Describe a suitable chemical test that could be used to distinguish between the following pairs of isomeric compounds. Include the expected observations for each test.

(a) propanol and propanone **2**

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(b) hex-3-ene and cyclohexane **2**

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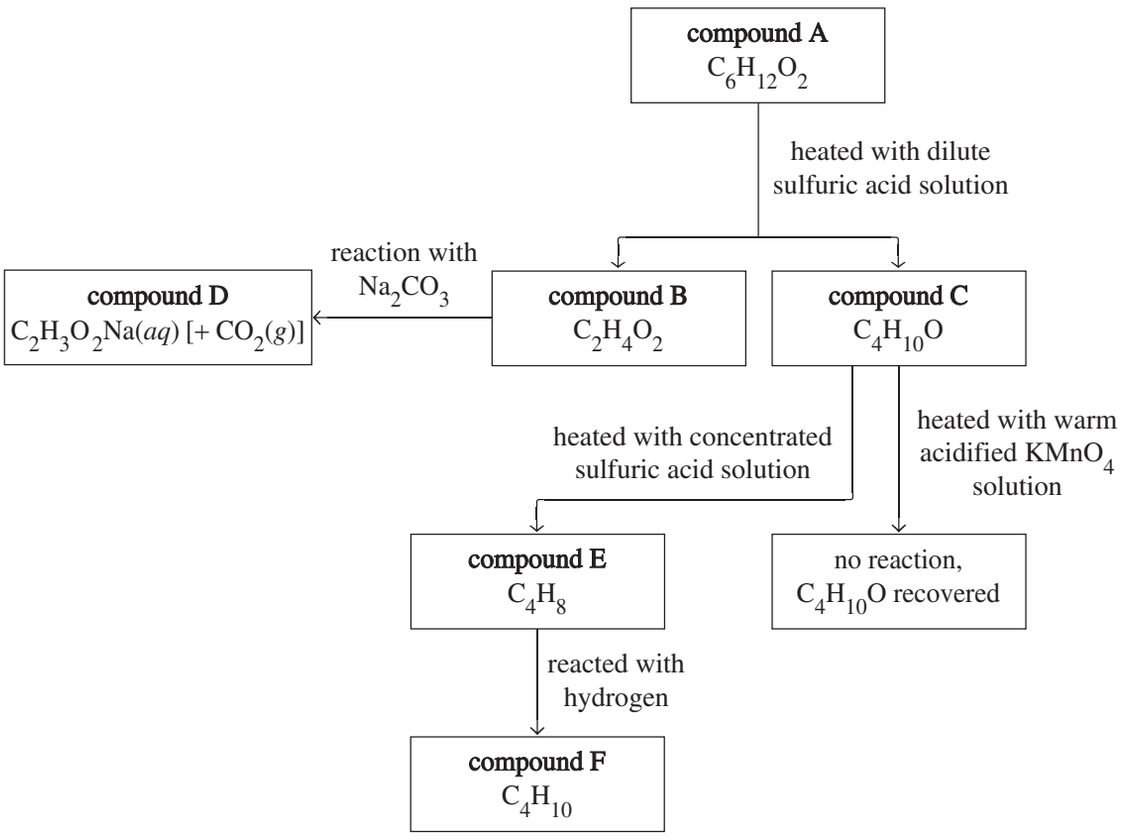
Question 28 (7 marks)

The flow chart shows reactions involving six different organic compounds, A–F. **7**



Draw the structural formula of compounds A–F and use the information provided to justify your answers.

Compound	*Structural formula*	*Justification*
A		
B		

Question 28 continues on page 18

Question 28 (continued)

C		
D		
E		
F		

End of Question 28

Question 29 (5 marks)

Some properties of but-1-ene, 1-fluoropropane, propan-1-ol and ethanamide are shown in the table. **5**

Compound	*Molar mass (g mol^{-1})*	*Solubility in water*
but-1-ene	56	insoluble
1-fluoropropane	62	slightly soluble
propan-1-ol	60	soluble
ethanamide	59	soluble

Explain the different water solubilities of these compounds. Support your answer with at least ONE labelled diagram.

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Question 30 (4 marks)

A comparison of two different industrial processes for the synthesis of phenol is shown in the table. **4**

	Industrial process A	*Industrial process B*
Chemical equations	$C_6H_6 + Cl_2 \rightarrow C_6H_5Cl + HCl$ $C_6H_5Cl + NaOH \rightarrow C_6H_5OH + NaCl$	$C_6H_6 + C_3H_6 \rightarrow C_6H_5C_3H_7$ $C_6H_5C_3H_7 + O_2 \rightarrow C_6H_5OH + C_3H_6O$
Capital cost	\$1 500 000 000	\$1 900 000 000
Chemical cost	\$270 000 000 per year	\$120 000 000 per year
Energy cost	\$100 000 000 per year	\$25 000 000 per year
Labour cost	\$3 500 000 per year	\$3 500 000 per year
Decommission cost	\$500 000 000	\$100 000 000
Lifetime of plant	15 years	25 years
Yield of C_6H_5OH	150 000 tonnes per year (98.0% pure)	200 000 tonnes per year (99.9% pure)
Other chemical products	HCl (to be stored or disposed) NaCl (to be stored or disposed)	C_3H_6O (sold as solvent)

Which of the two industrial processes is the better investment? Justify your answer with reference to yield and purity, economic costs and environmental impact.

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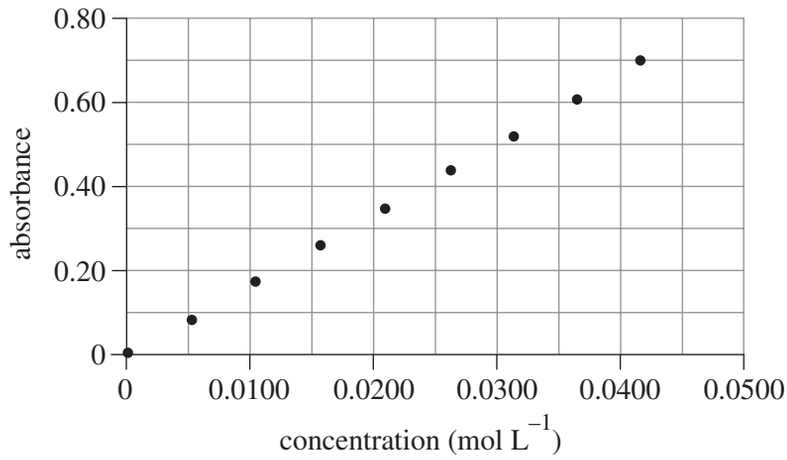
Question 31 (4 marks)

A colourimeter with an orange filter was used to analyse the concentration of copper ions in a solution **4**
To calibrate the colourimeter, a distilled water blank and eight standards of Cu^{2+} were prepared. Their absorbances were measured to give the calibration curve shown.



A 20.0 mL sample of a copper solution of unknown concentration was diluted to a total of volume of 80.0 mL. This diluted solution recorded an absorbance of 0.500.

Use the graph to determine the mass of the copper ions contained in the 20.0 mL sample.

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Question 32 (3 marks)

A sample of an unknown metal salt is to be analysed. The cation in the metal salt is known to be one of Ba^{2+}, Ca^{2+}, Mg^{2+} or Cu^{2+} and the anion is known to be one of Cl^{-}, OH^{-}, CO_3^{2-} or SO_4^{2-}. The metal salt is dissolved in water and the resulting colourless solution is divided into four equal samples to be tested, labelled A, B, C and D. The results of the tests are shown in the table. **3**

	Test(s) conducted	*Result*
Sample A	A solution of NaOH is added.	A white precipitate forms.
Sample B	Test 1: A dilute solution of HNO_3 is added.	There is no visible reaction.
	Test 2: A solution of $AgNO_3$ is added.	There is no visible reaction.
Sample C	Test 1: A solution of $BaCl_2$ is added.	A white precipitate forms.
	Test 2: A solution of HCl is added.	There is no visible reaction.
Sample D	A small sample of the solution was heated in the flame of a Bunsen burner.	The flame of the Bunsen burner does not change colour.

Identify the metal salt. Support your answer with at least ONE net ionic equation.

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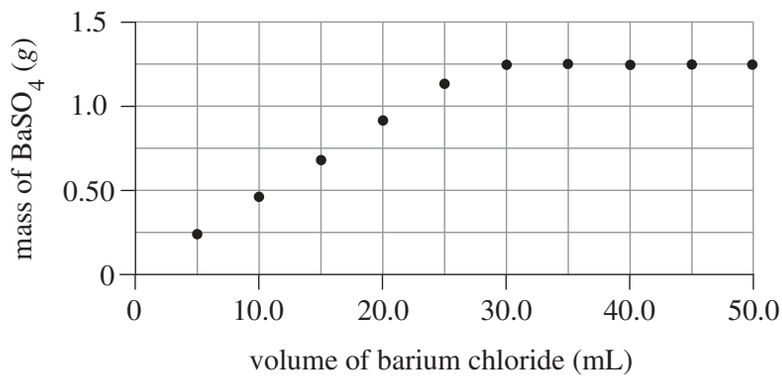
Question 33 (4 marks)

A gravimetric analysis was undertaken to determine the percentage, by mass, of sulfur in a sample of lawn fertiliser. A 10.4 g sample of fertiliser was dissolved into 250.0 mL of distilled water. This solution was then divided into ten equal 25.0 mL sub-samples. **4**

A barium chloride solution was added to each 25.0 mL sub-sample, and the resulting precipitate of barium sulfate was collected by filtration, dried and weighed. The graph shows the results of the gravimetric analysis.



Determine the percentage of sulfur, by mass, in the original sample of lawn fertiliser. Show all relevant working.

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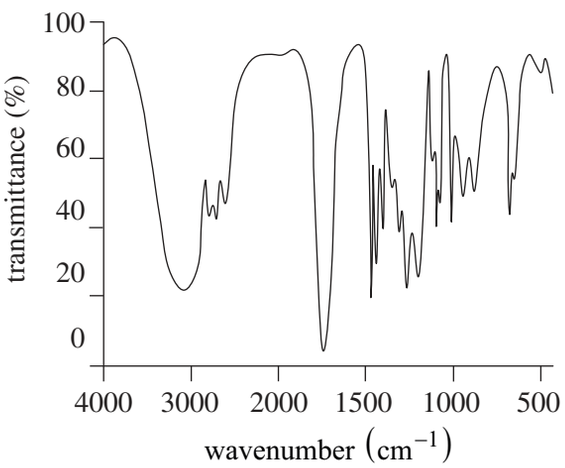
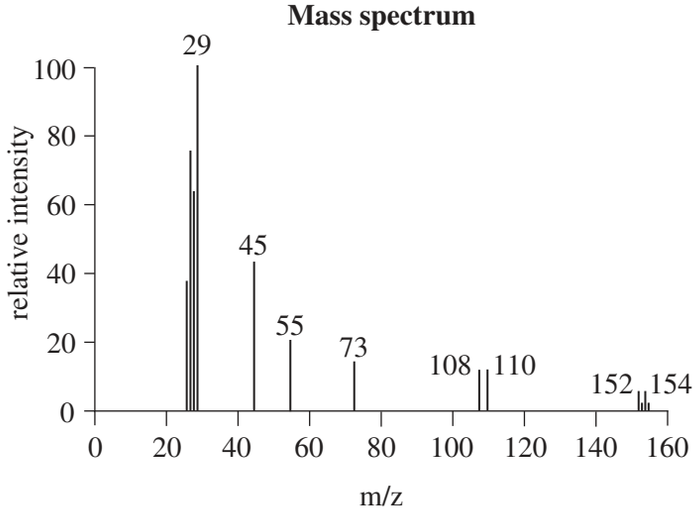
Question 34 (9 marks)

A series of preliminary tests on a small, water-soluble organic molecule revealed that it contained a halogen. The mass, infrared, ^{1}H NMR and ^{13}C NMR spectra of the unknown molecule are shown. **9**

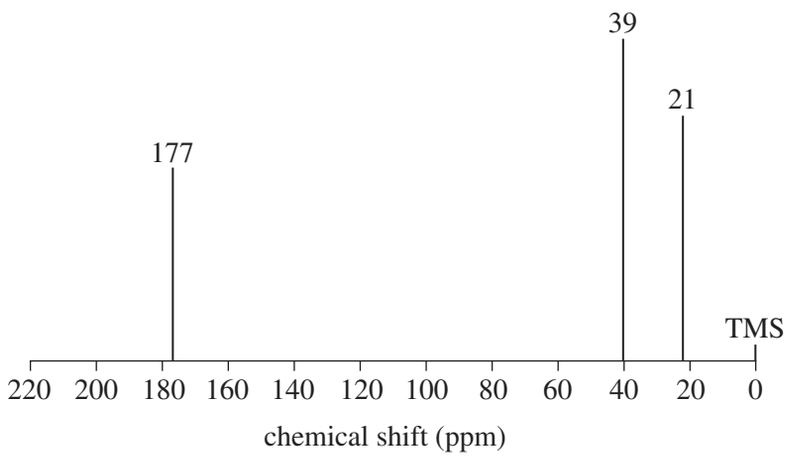
Infrared spectrum



Mass spectrum



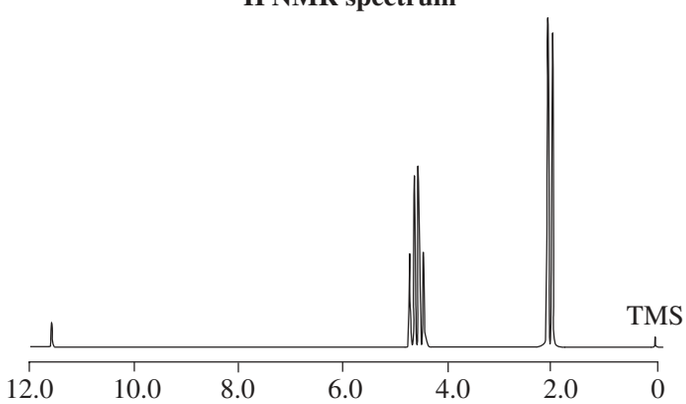
^{13}C NMR spectrum



Question 34 is continued on page 25

Question 34 (continued)

^{1}H NMR spectrum



Chemical shift (ppm)	*Peak splitting*	*Relative peak area*
1.9	doublet	3
4.4	quartet	1
11.5	singlet	1

In the space provided, draw a structural formula for the unknown molecule that is consistent with all of the information provided. Justify your answer with reference to the information provided.

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End of paper

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

FORMULAE SHEET

$$n = \frac{m}{MM} \qquad c = \frac{n}{V} \qquad PV = nRT$$

$$q = mc\Delta T \qquad \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \qquad \text{pH} = -\log_{10}[\text{H}^+]$$

$$pK_a = -\log_{10}[K_a] \qquad A = \varepsilon lc = \log_{10}\frac{I_o}{I}$$

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

Gas constant ..... 8.314 J mol^{-1} K^{-1}

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}

DATA SHEET

Solubility constants at 25°C

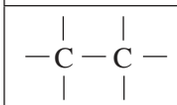
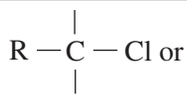
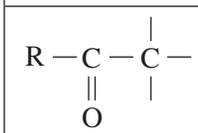
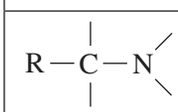
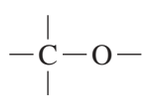
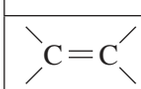
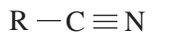
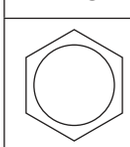
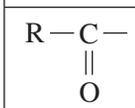
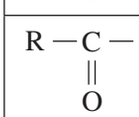
Compound	K_{sp}
Barium carbonate	2.58×10^{-9}
Barium hydroxide	2.55×10^{-4}
Barium phosphate	1.3×10^{-29}
Barium sulfate	1.08×10^{-10}
Calcium carbonate	3.36×10^{-9}
Calcium hydroxide	5.02×10^{-6}
Calcium phosphate	2.07×10^{-29}
Calcium sulfate	4.93×10^{-5}
Copper(II) carbonate	1.4×10^{-10}
Copper(II) hydroxide	2.2×10^{-20}
Copper(II) phosphate	1.40×10^{-37}
Iron(II) carbonate	3.13×10^{-11}
Iron(II) hydroxide	4.87×10^{-17}
Iron(III) hydroxide	2.79×10^{-39}
Iron(III) phosphate	9.91×10^{-16}

Compound	K_{sp}
Lead(II) bromide	6.60×10^{-6}
Lead(II) chloride	1.70×10^{-5}
Lead(II) iodide	9.8×10^{-9}
Lead(II) carbonate	7.40×10^{-14}
Lead(II) hydroxide	1.43×10^{-15}
Lead(II) phosphate	8.0×10^{-43}
Lead(II) sulfate	2.53×10^{-8}
Magnesium carbonate	6.82×10^{-6}
Magnesium hydroxide	5.61×10^{-12}
Magnesium phosphate	1.04×10^{-24}
Silver bromide	5.35×10^{-13}
Silver chloride	1.77×10^{-10}
Silver carbonate	8.46×10^{-12}
Silver hydroxide	2.0×10^{-8}
Silver iodide	8.52×10^{-17}
Silver phosphate	8.89×10^{-17}
Silver sulfate	1.20×10^{-5}

Infrared absorption data

Bond	Wavenumber/cm^{-1}
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550 (broad)
C—H	2850–3300
O—H (acids)	2500–3000 (very broad)
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

^{13}C NMR chemical shift data

Type of carbon	δ/ppm
	5–40
	10–70
	20–50
	25–60
 alcohols, ethers or esters	50–90
	90–150
	110–125
	110–160
 esters or acids	160–185
 aldehydes or ketones	190–220

UV absorption

(This is not a definitive list and is approximate.)

Chromophore	λ_{max} (nm)
C—H	112
C—C	135
C=C	162

Chromophore	λ_{max} (nm)
C≡C	173 178 196 222
C—Cl	173
C—Br	208

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 the standard potentials. 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	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson

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

Standard atomic weights are abridged to four significant figures.
Elements with no reported values in the table have no stable nuclides.
Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

Candidate Number:_____

Student Number

CHEMISTRY – MULTIPLE-CHOICE ANSWER SHEET

ATTEMPT ALL QUESTIONS

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