Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Wednesday 3 June 2009 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/3/

H 3 4 4 7 1 A 0 1 2 8

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The nucleus of a $^{23}_{11}Na$ atom contains

☒ **A** 11 protons and 12 neutrons.

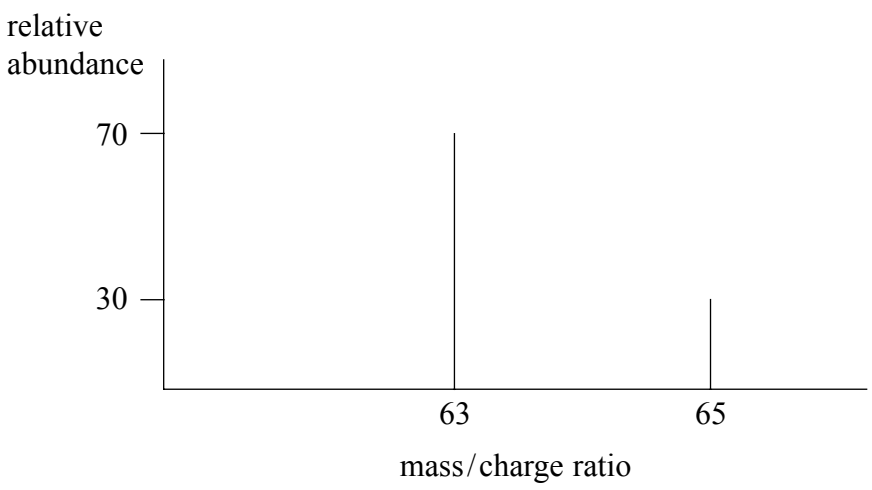
☒ **B** 11 protons and 12 electrons.

☒ **C** 23 protons and 11 neutrons.

☒ **D** 23 protons and 11 electrons.

(Total for Question 1 = 1 mark)

2 The mass spectrum for a sample of a metal is shown below.



The relative atomic mass of the metal is

☒ **A** 63.2

☒ **B** 63.4

☒ **C** 63.6

☒ **D** 64.0

(Total for Question 2 = 1 mark)

3 Some mean bond enthalpy values are given in the table below.

Bond	Mean bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

What is the enthalpy change for the reaction shown below in kJ mol^{-1}?

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

☒ **A** +436 + 151 – 299 = +288

☒ **B** –436 – 151 + 299 = –288

☒ **C** +436 +151 – (2 × 299) = –11

☒ **D** –436 – 151 + (2 × 299) = +11

(Total for Question 3 = 1 mark)

4 A compound was analysed and found to contain

1.45 g carbon 0.482 g hydrogen 1.69 g nitrogen

[Relative atomic masses: C = 12; H = 1; N = 14]

The empirical formula of the compound is

☒ **A** CH_3N

☒ **B** CH_4N

☒ **C** CH_5N

☒ **D** C_2H_4N

(Total for Question 4 = 1 mark)

5 17.1 g of aluminium sulfate, $Al_2(SO_4)_3$, was dissolved in water.

Calculate the number of sulfate ions, SO_4^{2-}, present in the solution formed.

[Assume the molar mass of $Al_2(SO_4)_3$ is 342 g mol^{-1} and the Avogadro Constant is 6×10^{23} mol^{-1}.]

☒ **A** 3×10^{21}

☒ **B** 1×10^{22}

☒ **C** 3×10^{22}

☒ **D** 9×10^{22}

(Total for Question 5 = 1 mark)

6 Calculate the mass of calcium hydroxide, $Ca(OH)_2$, present in 100 cm^3 of a 0.100 mol dm^{-3} solution.

[Assume the molar mass of $Ca(OH)_2$ is 74.0 g mol^{-1}.]

☒ **A** 0.570 g

☒ **B** 0.740 g

☒ **C** 1.85 g

☒ **D** 3.70 g

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 The first five successive ionization energies of an element, **X**, are shown in the table below.

Ionization energy	first	second	third	fourth	fifth
Value / kJ mol^{-1}	590	1100	4900	6500	8100

Which ion is **X** most likely to form when it reacts with chlorine?

☒ **A** X^+

☒ **B** X^{2+}

☒ **C** X^{3+}

☒ **D** X^{4+}

(Total for Question 7 = 1 mark)

8 Which of the following alkenes exhibits **E-Z** isomerism?

☒ **A** $H_3CCH{=}C(CH_3)_2$

☒ **B** $(CH_3)_2C{=}CH_2$

☒ **C** $H_2C{=}CHCH_2CH_3$

☒ **D** $H_3CCH{=}CHCH_3$

(Total for Question 8 = 1 mark)

9 Which of the following covalent bonds is the shortest?

☒ **A** H—F

☒ **B** H—Cl

☒ **C** H—Br

☒ **D** H—I

(Total for Question 9 = 1 mark)

10 Which of the following substances, obtained from the fractional distillation of crude oil, has the lowest boiling temperature?

☒ **A** refinery gas

☒ **B** kerosene

☒ **C** diesel oil

☒ **D** lubricating oil

(Total for Question 10 = 1 mark)

11 Sodium hydrogensulfate, $NaHSO_4$, reacts with sodium hydroxide, NaOH, as shown below.

$$NaHSO_4(aq) + NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$$

0.0100 mol of sodium hydrogensulfate is neutralized with dilute sodium hydroxide, concentration 0.200 mol dm^{-3}.

Calculate the volume of sodium hydroxide required.

☒ **A** 20.0 cm^3

☒ **B** 50.0 cm^3

☒ **C** 100 cm^3

☒ **D** 500 cm^3

(Total for Question 11 = 1 mark)

12 Which of the following ions would undergo the greatest deflection in a mass spectrometer?

☒ **A** $^{35}Cl^{2+}$

☒ **B** $^{35}Cl^{+}$

☒ **C** $^{37}Cl^{+}$

☒ **D** $^{35}Cl^{37}Cl^{+}$

(Total for Question 12 = 1 mark)

13 Which pair of atomic numbers represents elements which are both in the p-block of the Periodic Table?

☒ **A** 4, 8

☒ **B** 6, 12

☒ **C** 8, 16

☒ **D** 10, 20

(Total for Question 13 = 1 mark)

14 The electronic structure of an atom of an element in Group 6 of the Periodic Table could be

☒ **A** $1s^2\ 2s^2\ 2p^2$

☒ **B** $1s^2\ 2s^2\ 2p^4$

☒ **C** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

☒ **D** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$

(Total for Question 14 = 1 mark)

15 Which of the following formulae for compounds of germanium, Ge, is unlikely to be correct, given the position of germanium in the Periodic Table?

☒ **A** GeF_3

☒ **B** GeS_2

☒ **C** GeO_2

☒ **D** GeH_4

(Total for Question 15 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

16 The electronic configurations of the atoms of four different elements are given below. For which element would you expect the value of the first ionization energy to be the largest?

☒ **A** $1s^1$

☒ **B** $1s^2$

☒ **C** $1s^2\ 2s^1$

☒ **D** $1s^2\ 2s^2$

(Total for Question 16 = 1 mark)

17 Which of the following gas samples occupies the greatest volume at the same temperature and pressure?

[Relative atomic masses: H = 1; C = 12; O = 16; F = 19; Ne = 20]

☒ **A** 1 gram of ethane

☒ **B** 1 gram of oxygen

☒ **C** 1 gram of fluorine

☒ **D** 1 gram of neon

(Total for Question 17 = 1 mark)

18 Which of the following has the smallest ionic radius?

☒ **A** F^-

☒ **B** Na^+

☒ **C** Mg^{2+}

☒ **D** O^{2-}

(Total for Question 18 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

19 Which of the following does **not** have exactly 10 electrons?

☒ **A** An ion of fluorine, F^-

☒ **B** A molecule of methane, CH_4

☒ **C** A molecule of nitrogen, N_2

☒ **D** An ion of sodium, Na^+

(Total for Question 19 = 1 mark)

20 Which of the following statements correctly describes an environmental problem caused by the burning of hydrocarbon fuels?

☒ **A** The carbon dioxide is toxic and kills plants.

☒ **B** The smoke produced reflects sunlight and leads to global warming.

☒ **C** The water produced results in a damaging increase in rainfall.

☒ **D** The carbon dioxide produced absorbs heat radiated from the Earth and leads to global warming.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

Use this space for any rough working. Anything you write in this space will gain no credit.

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 This question is about hydrocarbons.

(a) Liquefied petroleum gas (LPG) is a fuel sold as an alternative to petrol. It is a mixture of liquefied C_3 and C_4 alkanes.

(i) Suggest a reason why the alkanes are liquefied.

(1)

.....

.....

(ii) There are two C_4 alkanes.

Draw **skeletal** formulae of each of the C_4 alkanes in the spaces provided.

Name each alkane.

(4)

First skeletal formula	Second skeletal formula
Name:	Name: .....

(iii) Complete the following sentence.

(1)

Compounds with the same molecular formula but different structural formula are called .....

(b) Propane, C_3H_8, reacts with chlorine, Cl_2, in a substitution reaction.

$$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$$

The mechanism for this reaction is described in three stages.

(i) Give the **initiation step** for this reaction and state the condition necessary for this step to occur.

(2)

Initiation step

Condition .....

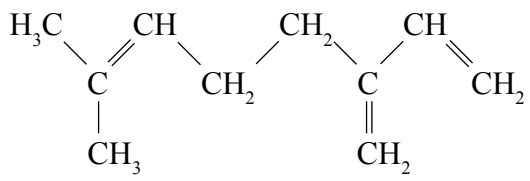
(ii) Give the TWO **propagation steps** for this reaction.

(2)

(iii) Give a possible **termination step** for this reaction.

(1)

(c) Myrcene, $C_{10}H_{16}$, is a naturally occurring compound which is used in perfumes.



Myrcene

(i) Name the functional group in myrcene.

(1)

.....

(ii) What colour change would you observe when bromine, dissolved in an organic solvent, is added to myrcene?

(1)

From ..... **To** .....

(iii) Classify the type and mechanism of the reaction that occurs when myrcene reacts with bromine, Br_2.

(2)

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(iv) In an experiment, 1.36 g of myrcene (molar mass: 136 g mol^{-1}) was found to react with 0.72 dm^3 of hydrogen, H_2, in the presence of a nickel catalyst.

Use this information to draw the structural formula of the product of the reaction between myrcene and hydrogen.

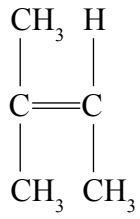
[Assume the molar volume of H_2 under the conditions of the experiment is 24 $dm^3\,mol^{-1}$.]

(2)

Calculation

Hence structural formula of the product

(d) Myrcene is one of a group of compounds related to 2-methylbut-2-ene shown below.



2-methylbut-2-ene undergoes addition polymerization in a similar way to ethene.

Draw the structural formula of the repeat unit of the polymer formed.

(2)

(Total for Question 21 = 19 marks)

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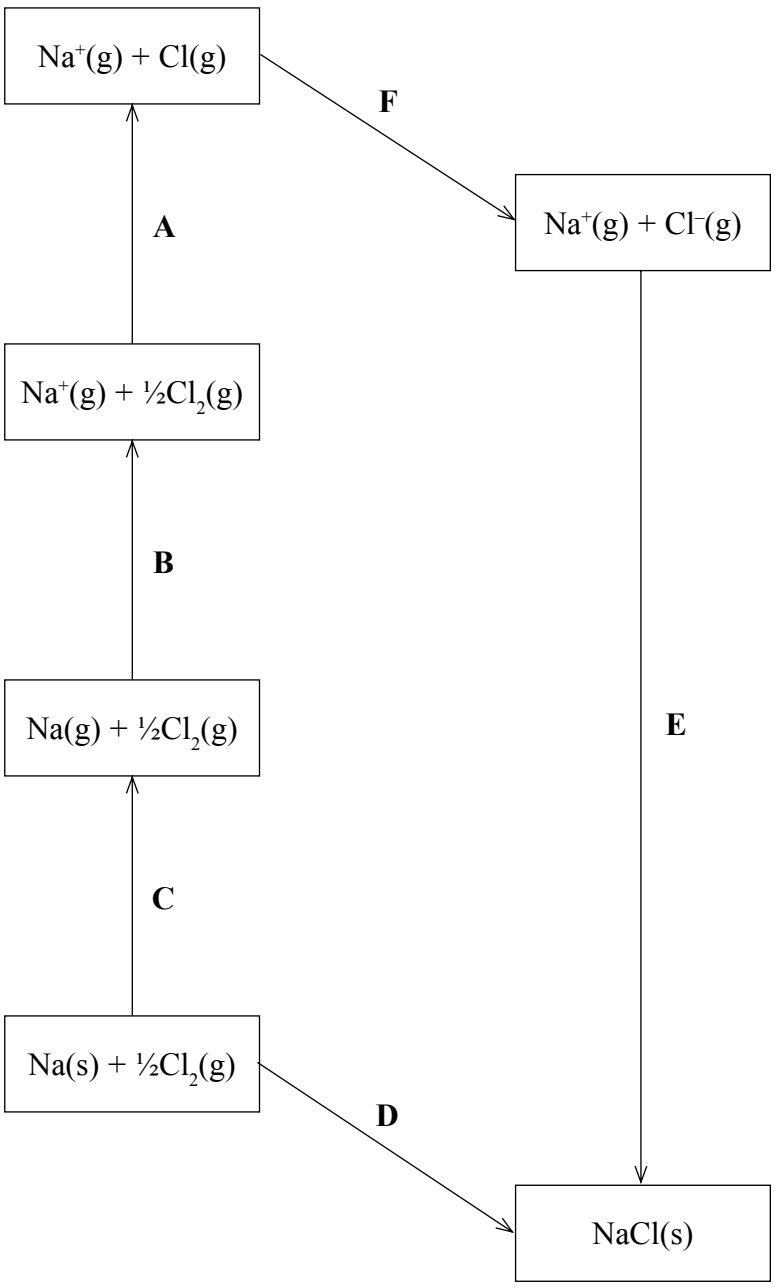
22 The Born-Haber cycle for the formation of sodium chloride from sodium and chlorine may be represented by a series of steps labelled **A** to **F** as shown.



(a) (i) Complete the table below by adding the letters **A** to **F** next to the corresponding energy changes.

(3)

Energy change	Letter	ΔH /kJ mol^{-1}
Lattice energy for sodium chloride		–775
Enthalpy change of atomization of sodium		+109
Enthalpy change of atomization of chlorine		+121
First ionization energy of sodium		+494
First electron affinity of chlorine		
Enthalpy change of formation of sodium chloride		–411

(ii) Calculate the first electron affinity of chlorine, in kJ mol^{-1}, from the data given.

(2)

(b) Lattice energies can be calculated from electrostatic theory (theoretical values) as well as by Born-Haber cycles (experimental values).

Compound	Experimental lattice energy / kJ mol^{-1}	Theoretical lattice energy / kJ mol^{-1}
NaCl	–770	–766
AgI	–889	–778

(i) Comment on the fact that there is close agreement between the values for sodium chloride, NaCl.

(1)

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*(ii) Explain, in terms of chemical bonding, why the experimental value for silver iodide, AgI, is more exothermic than the value calculated theoretically for the same compound.

(2)

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*(c) Suggest why the first ionization energies of the Group 1 elements decrease down the group.

(2)

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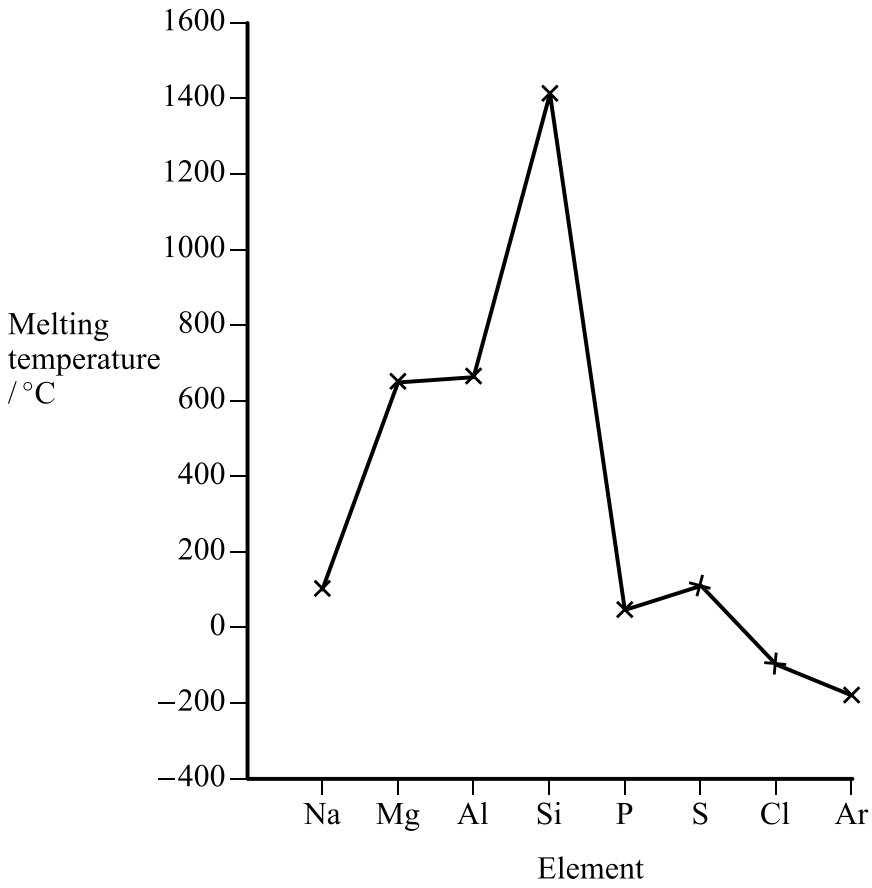
(Total for Question 22 = 10 marks)

23 The graph shows the variation in melting temperatures of the elements across Period 3 (Na to Ar) of the Periodic Table.



(a) Complete the table below to show the type of structure and bonding for the elements shown.

(3)

Element	Structure	Bonding
sodium		
silicon		
sulfur		

(b) Explain why silicon has a much higher melting temperature than sulfur.

(2)

*(c) Explain why the melting temperature increases from sodium to aluminium.

(2)

(d) Magnesium forms the basic oxide magnesium oxide, MgO. This oxide is almost insoluble in water. On gentle warming with dilute sulfuric acid, magnesium oxide reacts to form aqueous magnesium sulfate solution.

*(i) Describe how you would use the above reaction to prepare a pure sample of magnesium sulfate.

(5)

(ii) Suggest what action should be taken if a pupil spilt a small quantity of dilute sulfuric acid on a laboratory bench.

(1)

(e) The data in the table below will be useful when answering this question.

Soluble in water	Insoluble in water
$MgSO_4$	$MgCO_3$ $SrCO_3$ $SrSO_4$

Magnesium carbonate reacts with dilute sulfuric acid.

$$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + CO_2(g) + H_2O(l)$$

(i) Explain why the reaction between strontium carbonate and dilute sulfuric acid stops after a few seconds.

(1)

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(ii) Strontium sulfate is produced when aqueous sodium sulfate is added to aqueous strontium chloride.

Give the **ionic** equation for the reaction, including state symbols.

(2)

(Total for Question 23 = 16 marks)

24 Propanone, C_3H_6O, undergoes complete combustion to form carbon dioxide and water.

$$C_3H_6O(l) + 4O_2(g) \rightarrow 3CO_2(g) + 3H_2O(l)$$

(a) In an experiment to calculate the enthalpy change of combustion for propanone, 2.90 g of propanone was burned completely in oxygen.

The heat energy from this combustion raised the temperature of 200 g of water from 20.2 °C to 78.4 °C.

The specific heat capacity of water is 4.18 J g^{-1} $°C^{-1}$.

(i) Calculate the number of moles of propanone present in 2.90 g.

[The molar mass of propanone is 58 g mol^{-1}.]

(1)

(ii) Use the expression

$$\text{energy transferred (J)} = \text{mass} \times \frac{\text{specific heat}}{\text{capacity}} \times \frac{\text{temperature}}{\text{change}}$$

to calculate the heat energy transferred to raise the temperature of 200 g of water from 20.2 °C to 78.4 °C.

(2)

(iii) Use your answers to (a)(i) and (ii) to calculate a value for the enthalpy change of combustion of propanone. Give your answer to **three** significant figures and include a sign and units.

(3)

(b) In another experiment, the enthalpy change of combustion for butanone, C_4H_8O, was found to be –1300 kJ mol^{-1}.

A Data Book value for the standard enthalpy change of combustion for butanone is –2440 kJ mol^{-1}.

(i) Suggest a reason why the value obtained in the experiment is so different from the Data Book value.

(1)

.....

(ii) This Data Book value (–2440 kJ mol^{-1}) refers to the following equation.

$$C_4H_8O(l) + 6½O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l)$$

How would the value be different if it referred to the formation of water in the **gaseous** state? Justify your answer.

(2)

Difference .....

Justification .....

.....

.....

.....

(c) Standard enthalpy changes of combustion can be used to calculate the standard enthalpy change of formation of a compound.

(i) Define the term **standard enthalpy change of formation**, making clear the meaning of **standard** in this context.

(3)

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(ii) Use the standard enthalpy changes of combustion, $\Delta H_c^{\ominus}$, given in the table below to find the standard enthalpy change of formation for ethanoic acid, CH_3COOH, in kJ mol^{-1}.

Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s, graphite)	–394
$H_2(g)$	–286
$CH_3COOH(l)$	–870

$$2C(s, \text{graphite}) + 2H_2(g) + O_2(g) \rightarrow CH_3COOH(l)$$

(3)

(Total for Question 24 = 15 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass; atomic symbol; name; atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103