Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2009

Chemistry CHEM1

Unit 1 Foundation Chemistry

Wednesday 3 June 2009 9.00 am to 10.15 am

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. **Answers written in margins or on blank pages will not be marked.**
- All working must be shown.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The Periodic Table/Data Sheet is provided as an insert.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

Areas outside the box will not be scanned for marking

SECTION A

Answer **all** questions in the spaces provided.

1 (a) Complete the electronic configuration for the sodium ion, Na^+

$1s^2$ ....

(1 mark)

1 (b) (i) Write an equation, including state symbols, to represent the process for which the energy change is the second ionisation energy of sodium.

....

(2 marks)

1 (b) (ii) Explain why the second ionisation energy of sodium is greater than the second ionisation energy of magnesium.

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....

(3 marks)

1 (b) (iii) An element **X** in Period 3 of the Periodic Table has the following successive ionisation energies.

	First	Second	Third	Fourth
Ionisation energies / kJ mol^{-1}	577	1820	2740	11600

Deduce the identity of element **X**.

....

(1 mark)

1 (c) State and explain the trend in atomic radius of the Period 3 elements from sodium to chlorine.

Trend ....

Explanation ....

....

....

(3 marks)

1 (d) Explain why sodium has a lower melting point than magnesium.

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(3 marks)

1 (e) Sodium reacts with ammonia to form the compound $NaNH_2$ which contains the NH_2^- ion. Draw the shape of the NH_2^- ion, including any lone pairs of electrons. Name the shape made by the three atoms in the NH_2^- ion.

Shape of NH_2^-

Name of shape ....

(2 marks)

1 (f) In terms of its electronic configuration, give **one** reason why neon does not form compounds with sodium.

....

(1 mark)

16

Turn over ▶

2 Under suitable conditions magnesium will react with dilute nitric acid according to the following equation.

$$Mg(s) + 2HNO_3(aq) \longrightarrow Mg(NO_3)_2(aq) + H_2(g)$$

A 0.0732 g sample of magnesium was added to 36.4 cm^3 of 0.265 mol dm^{-3} nitric acid. The acid was in excess.

2 (a) (i) Calculate the amount, in moles, of magnesium in the 0.0732 g sample.

....

....

(1 mark)

2 (a) (ii) Hence calculate the amount, in moles, of nitric acid needed to react completely with this sample of magnesium.

....

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(1 mark)

2 (a) (iii) Calculate the amount, in moles, of nitric acid originally added to this sample of magnesium.

....

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(1 mark)

2 (a) (iv) Hence calculate the amount, in moles, of nitric acid that remains unreacted.

....

....

(1 mark)

Areas outside the box will not be scanned for marking

2 (b) In a second experiment, 0.512 mol of hydrogen gas was produced when another sample of magnesium reacted with dilute nitric acid. Calculate the volume that this gas would occupy at 298 K and 96 kPa. Include units in your final answer.
(The gas constant $R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$)

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(3 marks)

2 (c) Concentrated nitric acid reacts with magnesium to form an oxide of nitrogen which contains 30.4% by mass of nitrogen.

Calculate the empirical formula of this oxide of nitrogen. Show your working.

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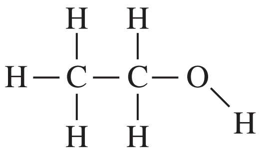
(3 marks)

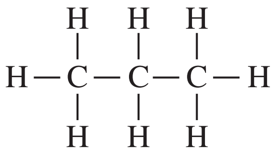
10

Turn over for the next question

3 (a) Two organic compounds with similar relative molecular masses are shown below.



Ethanol



Propane

3 (a) (i) State the type of bond present between the C and H atoms in both of these molecules. Explain how this type of bond is formed.

Type of bond ....

Explanation ....

....

(2 marks)

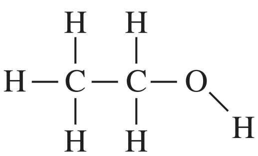
3 (a) (ii) State the strongest type of intermolecular force present in each compound.

Liquid ethanol ....

Liquid propane ....

(2 marks)

3 (b) Ethanol dissolves in water. Draw a diagram to show how one molecule of ethanol interacts with one molecule of water in the solution. Include partial charges and all lone pairs. The ethanol molecule has been drawn for you.



(3 marks)

Areas outside the box will not be scanned for marking

3 (c) Ethanol was the fuel used in the first mass-produced car, the Model T Ford.

3 (c) (i) Write an equation which shows how ethanol burns completely in air to form carbon dioxide and water as the only products.

....

(1 mark)

3 (c) (ii) Suggest **one** environmental problem caused by incomplete combustion of ethanol in a car engine.

....

....

(1 mark)

3 (c) (iii) Suggest **one** economic problem for the car user caused by incomplete combustion of ethanol in the car engine.

....

....

(1 mark)

3 (d) Propane is also used as a fuel, although sometimes it can be contaminated with sulfur-containing impurities. When this propane burns, these impurities form sulfur dioxide.

3 (d) (i) State how the sulfur dioxide can be removed from the waste gases produced when this propane is burned on a large scale in industry. Suggest a reason why the method you have stated may not be 100% efficient.

How removed ....

....

Reason for less than 100% efficiency ....

....

(2 marks)

3 (d) (ii) Although propane has a boiling point of −42 °C, it is usually supplied as a liquid for use in camping stoves. Suggest why it is supplied as a liquid.

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(1 mark)

13

Turn over ▶

Areas outside the box will not be scanned for marking

4 Hexane is a member of the homologous series of alkanes.

4 (a) State **two** characteristics of a *homologous series*.

Characteristic 1 ....

....

Characteristic 2 ....

....

(2 marks)

4 (b) (i) Hexane can be converted into 2,2-dichlorohexane.

Draw the displayed formula of 2,2-dichlorohexane and deduce its empirical formula.

Displayed formula

Empirical formula ....

....

(2 marks)

4 (b) (ii) Explain why 2,2-dichloro-3-methylpentane is a structural isomer of 2,2-dichlorohexane.

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(2 marks)

4 (c) A reaction of hexane with chlorine is shown by the equation below.

$$C_6H_{14} + 2Cl_2 \longrightarrow C_6H_{12}Cl_2 + 2HCl$$

Calculate the percentage atom economy for the formation of $C_6H_{12}Cl_2$ in this reaction.

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(2 marks)

4 (d) The boiling points of some straight-chain alkanes are shown below.

Alkane	C_4H_{10}	C_5H_{12}	C_6H_{14}
Boiling point / °C	–0.5	36.3	68.7

4 (d) (i) Explain the trend in these boiling points.

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....

....

(2 marks)

4 (d) (ii) Name a process which can be used to separate C_5H_{12} from C_6H_{14}

....

(1 mark)

11

Turn over ▶

SECTION B

Answer Question **5** in the spaces provided.

5 (a) (i) Define the term *relative atomic mass* (A_r) of an element.

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(2 marks)

5 (a) (ii) A sample of the metal silver has the relative atomic mass of 107.9 and exists as two isotopes. In this sample, 54.0% of the silver atoms are one isotope with a relative mass of 107.1

Calculate the relative mass of the other silver isotope.

State why the isotopes of silver have identical chemical properties.

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(4 marks)

5 (b) The isotopes of silver, when vaporised, can be separated in a mass spectrometer.

Name the **three** processes that occur in a mass spectrometer before the vaporised isotopes can be detected.

State how each process is achieved.

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(6 marks)

Question 5 continues on the next page

Turn over ▶

5 (c) State the type of bonding involved in silver.

Draw a diagram to show how the particles are arranged in a silver lattice and show the charges on the particles.

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(3 marks)

Areas outside the box will not be scanned for marking

5 (d) Silver reacts with fluorine to form silver fluoride (AgF).

Silver fluoride has a high melting point and has a structure similar to that of sodium chloride.

State the type of bonding involved in silver fluoride.

Draw a diagram to show how the particles are arranged in a silver fluoride lattice and show the charges on the particles.

Explain why the melting point of silver fluoride is high.

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(5 marks)

20

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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INSERT TO/APW/Jun09/CHEM1

GCE Chemistry Data Sheet

Table 1

Infrared absorption data

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

Table 2

^{1}H n.m.r. chemical shift data

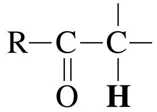
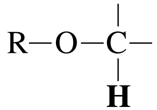
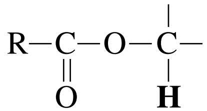
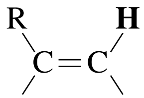
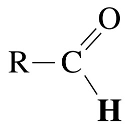
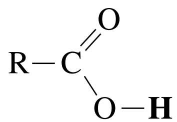
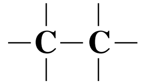
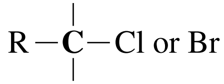
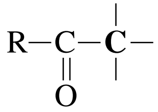
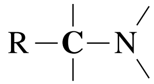
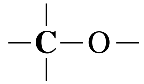
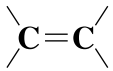
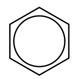
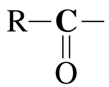
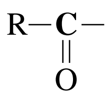
Type of proton	δ/ppm
RO**H**	0.5–5.0
RC**H**$_3$	0.7–1.2
RN**H**$_2$	1.0–4.5
R$_2$C**H**$_2$	1.2–1.4
R$_3$C**H**	1.4–1.6
	2.1–2.6
	3.1–3.9
RC**H**$_2$Cl or Br	3.1–4.2
	3.7–4.1
	4.5–6.0
	9.0–10.0
	10.0–12.0

Table 3

^{13}C n.m.r. chemical shift data

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

The Periodic Table of the Elements

Key

relative atomic mass
symbol
name
atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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											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	96.0 **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	[267] **Rf** rutherfordium 104	[268] **Db** dubnium 105	[271] **Sg** seaborgium 106	[272] **Bh** bohrium 107	[270] **Hs** hassium 108	[276] **Mt** meitnerium 109	[281] **Ds** darmstadtium 110	[280] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

*** 58 – 71** Lanthanides	140.1 **Ce** cerium 58	140.9 **Pr** praseodymium 59	144.2 **Nd** neodymium 60	[145] **Pm** promethium 61	150.4 **Sm** samarium 62	152.0 **Eu** europium 63	157.3 **Gd** gadolinium 64	158.9 **Tb** terbium 65	162.5 **Dy** dysprosium 66	164.9 **Ho** holmium 67	167.3 **Er** erbium 68	168.9 **Tm** thulium 69	173.1 **Yb** ytterbium 70	175.0 **Lu** lutetium 71
† 90 – 103 Actinides	232.0 **Th** thorium 90	231.0 **Pa** protactinium 91	238.0 **U** uranium 92	[237] **Np** neptunium 93	[244] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[247] **Bk** berkelium 97	[251] **Cf** californium 98	[252] **Es** einsteinium 99	[257] **Fm** fermium 100	[258] **Md** mendelevium 101	[259] **No** nobelium 102	[262] **Lr** lawrencium 103