Surname	Other Names										
Centre Number Candidate Number											
Candidate Signate	ure										·

For Examiner's Use

General Certificate of Education June 2008 Advanced Subsidiary Examination



# CHEMISTRY CHM1 Unit 1 Atomic Structure, Bonding and Periodicity

Wednesday 4 June 2008 9.00 am to 10.00 am

For this paper you must have

a calculator.

Time allowed: 1 hour

### **Instructions**

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer all questions.
- Answer the questions in Section A and Section B in the spaces provided. Answers written in margins or blank pages will not be marked.
- All working must be shown.

- Do all rough work in this book. Cross through any work you do not want to be marked.
- The Periodic Table/Data Sheet is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

#### **Information**

- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.

#### **Advice**

• You are advised to spend about 45 minutes on **Section A** and about 15 minutes on **Section B**.

For Examiner's Use					
Question	Mark	Question	Mark		
1					
2					
3					
4					
5					
6					
Total (Co	lumn 1)	$\rightarrow$			
Total (Co	lumn 2) –	$\rightarrow$			
TOTAL					
Examine	r's Initials				

## **SECTION A**

			Answer all question	ons in the	spaces pi	rovided.			
1	(a)	State,	in terms of protons and neut	trons, the	meaning	of the ter	rm isotope	es.	
				•••••	•••••	•••••	•••••	•••••	
					•••••				
								(1 m	 ark)
1	(b)		able below gives the relative le of lead, Pb	abundand	ce of each	isotope i	in a mass	spectrum of	a
			m/z	204	206	207	208		
			Relative abundance (%)	1.5	23.6	21.4	53.5		
			hese data to calculate the relater to <b>one</b> decimal place.	ative aton	nic mass o	of this sar	mple of le	ad. Give yo	our
		•••••						(2 mc	 ırks)



0	4.0 <b>He</b> Helium 2	20.2 <b>Ne</b> Neon	39.9 <b>Ar</b> Argon 18	83.8 <b>Kr</b> Krypton 36	131.3 <b>Xe</b> Xenon 54	222.0 <b>Rn</b> Radon 86	
<b>=</b>		19.0 <b>F</b> Fluorine 9	35.5 <b>CI</b> Chlorine 17	79.9 <b>Br</b> Bromine 35	126.9 <b> </b>   lodine   53	210.0 <b>At</b> Astatine 85	
>		16.0 <b>O</b> Oxygen 8	32.1 <b>S</b> Sulphur 16	Selenium	127.6 <b>Te</b> Tellurium 52	210.0 <b>Po</b> Polonium 84	
>		14.0 <b>N</b> Nitrogen 7	31.0 <b>P</b> Phosphorus	72.6 74.9 76 AS Germanium Arsenic 33 33 (2.2)	<b>Sb</b> Antimony 51	209.0 <b>Bis</b> Bismuth 83	
≥		12.0 <b>C</b> Carbon 6	27.0 28.1 <b>Si</b> Aluminium Silicon 13	72.6 <b>Ge</b> Germanium 32	<b>Sn</b> Tin	207.2 <b>Pb</b> Lead 82	
=		10.8 <b>B</b> Boron 5	27.0 <b>AI</b> Aluminium 13	69.7 <b>Ga</b> Gallium 31	114.8 <b>In</b> Indium 49	204.4 <b>TI</b> Thallium 81	
				65.4 <b>Zn</b> Zinc 30	112.4 <b>Cd</b> Cadmium 48	200.6 <b>Hg</b> Mercury 80	
				63.5 <b>Cu</b> Copper 29	107.9 <b>Ag</b> Silver 47	197.0 <b>Au</b> Gold 79	
				58.7 <b>Nickel</b> Nickel 28	106.4 <b>Pd</b> Palladium 46	195.1 <b>Pt</b> Platinum 78	
				58.9 <b>Co</b> Cobalt 27	102.9 <b>Rh</b> Rhodium 45	192.2 <b>Ir</b> Iridium 77	
				55.8 <b>Fe</b> Iron 26	101.1 <b>Ru</b> Ruthenium 44	190.2 <b>Os</b> Osmium 76	
		6.9 <b>Li</b> Lithium 3		52.0   54.9   55.8	95.9         98.9         101.1         102.9         106.4           Мо         Tc         Ru         Rh         Pd           Моlуbdenum         Technetium         Ruthenium         Rhodium         Palladium           42         43         44         45         46	186.2 190.2 <b>Re Os</b> Rhenium Osmium 75 76	
		388		52.0 <b>Cr</b> Chromium 24	95.9 <b>Mo</b> Molybdenum 42	183.9 <b>W</b> Tungsten 74	
		relative atomic mass atomic number		50.9 <b>V</b> Vanadium 23	92.9 <b>Nb</b> Niobium 41	180.9 <b>Ta</b> Tantalum 73	
	Key	relative atomic ı atomic ı		47.9 <b>Ti</b> Titanium 22	91.2 <b>Zr</b> Zirconium 40	178.5 <b>#</b> Hafnium 72	
				Scandium 21	88.9 <b>4</b> Yttrium 39	138.9 <b>La</b> Lanthanum 57 *	Actinium
=		9.0 <b>Be</b> Beryllium 4	24.3 <b>Mg</b> Magnesium 12	40.1 <b>Ca</b> Calcium 20	87.6 Strontium	137.3 <b>Ba</b> Barium 56	226.0 <b>Ra</b> Radium
-	1.0 <b>H</b> Hydrogen 1	6.9 <b>Li</b> Lithium	23.0 <b>Na</b> Sodium		85.5 <b>Rb</b> Rubidium 37	132.9 <b>Cs</b> Caesium 55	223.0 <b>Fr</b> Francium 87

- ************************************	140.1 <b>Ce</b>	Ce Pr 140.9	. 5	144.9 <b>Pm</b>	150.4 <b>Sm</b>	152.0 <b>Eu</b>	157.3 <b>Gd</b>	158.9 <b>Tb</b>	162.5 <b>Dy</b>	164.9 <b>Ho</b>	167.3 <b>Er</b>	168.9 <b>Tm</b>	173.0 <b>Yb</b>	175.0 <b>Lu</b>
<b>38 - 71</b> Lantnanides	Cerium 58	Cerium Praseodymium Neody 59 60	minm	Promethium 61	Ε	Europium 33		Terbium 65	Dysprosiur 66	n Holmium 67				Lutetium 71
4 00 A	232.0 <b>Th</b>	232.0 231.0 238. <b>Th Pa</b>	o <b>_</b>		239.1 2	243.1 <b>Am</b>	247.1 <b>Cm</b>	247.1 <b>Bk</b>	252.1 <b>Cf</b>	(252) <b>Es</b>	Ë	(258) <b>Md</b>		(260) <b>Lr</b>
T <b>90 - 103</b> Actinides	Thorium 90	Protactinium 91	nium	Neptunium 93	Plutonium 94	Americium 35		Berkelium 97	Californiur 98	Einsteinium 99	Fermium 100	Mendelev 101	Nobelium 102	Lawrencium 103

Gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ 

**Table 1** Proton n.m.r chemical shift data

Type of proton	δ/ppm
$RCH_3$	0.7–1.2
$R_2CH_2$	1.2–1.4
$R_3CH$	1.4–1.6
$RCOCH_3$	2.1–2.6
$ROCH_3$	3.1–3.9
$RCOOCH_3$	3.7–4.1
ROH	0.5–5.0

**Table 2** Infra-red absorption data

Bond	Wavenumber/cm <sup>-1</sup>
С—Н	2850-3300
С—С	750–1100
C=C	1620–1680
C=O	1680–1750
С—О	1000-1300
O—H (alcohols)	3230-3550
O—H (acids)	2500-3000

	1	(c)	Lead is	sused	in lead-aci	d car	batteries
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**1** (c) (i) Balance the equation, given below, for the overall reaction which occurs when a lead-acid battery produces a current.

$$PbO_2 + Pb + \dots H_2SO_4 \longrightarrow \dots PbSO_4 + \dots H_2O$$

1 (c) (ii) State what chemical difference there will be, if any, if the lead used in the above reaction is  $^{204}$ Pb rather than  $^{206}$ Pb. Explain your answer.

Chemical difference	
Explanation	
	(3 marks)

(5 mark

1 (d) An atom has four times the number of protons, and three times the number of neutrons, as there are in the <sup>7</sup>Li atom.

Deduce the symbol, including the mass number, of this atom.

(2 marks)

- 1 (e) Before deflection or detection can occur in a mass spectrometer, a sample of gaseous atoms must first be ionised.
- 1 (e) (i) Explain how gaseous atoms are ionised in a mass spectrometer.

(ii) Identify another process in a mass spectrometer, apart from deflection and

detection, which depends on the sample being ionised.

(3 marks)

2	(a)	• •	gen may be prepared by the decomposition of hydrogen peroxide, H <sub>2</sub> O <sub>2</sub> , as shown e equation below.
			$2H_2O_2(aq) \longrightarrow 2H_2O(1) + O_2(g)$
			50 cm <sup>3</sup> sample of 2.72 mol dm <sup>-3</sup> aqueous hydrogen peroxide was decomposed pletely.
			ulate the number of moles of hydrogen peroxide in the 150 cm <sup>3</sup> sample and hence ice the number of moles of oxygen gas produced.
		Mole	es of $H_2O_2$ in sample
		Mole	es of $O_2$ produced
		•••••	(3 marks)
2	(b)		sphine, PH <sub>3</sub> , and oxygen can react to form phosphoric acid, H <sub>3</sub> PO <sub>4</sub> , as shown in equation below.
			$PH_3 + 2O_2 \longrightarrow H_3PO_4$
			excess of oxygen was mixed with 1.43 g of phosphine in a sealed container and wed to react.
2	(b)	(i)	Calculate the number of moles of PH <sub>3</sub> in 1.43 g of phosphine.
2	(b)	(ii)	Calculate the number of moles of oxygen which reacted with this amount of phosphine.
2	(b)	(iii)	Calculate the mass of phosphoric acid formed in this reaction.

2	(c)	After the reaction in part (b) was complete, 0.166 mol of oxygen was left unreacted. The final temperature was 300 K. The volume of the sealed container was 1725 cm <sup>3</sup> .
		State the ideal gas equation and use it to calculate the pressure of the oxygen in the container after the reaction was complete. (The gas constant $R = 8.31 \mathrm{J  K^{-1}  mol^{-1}}$ )
		Ideal gas equation
		Pressure
		(4 marks)

Turn over for the next question



3	(a)	State the meaning of the term <i>first ionisation energy</i> of an atom.
3	(b)	Explain why there is a general increase in the first ionisation energies of the Period 3 elements Na to Ar
		(2 marks)
3	(c)	State how the first ionisation energy of sulphur deviates from the general trend in part (b). Explain your answer.
		Deviation of sulphur from the general trend
		Explanation
		(3 marks)



 ${f 3}$  (d) (i) Draw the shape of a BF $_3$  molecule and the shape of a H $_2$ S molecule. In each case show any lone pairs of electrons.

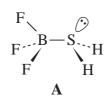
 $BF_3$ 

 $H_2S$ 

**3** (d) (ii) Explain why a BF<sub>3</sub> molecule has the shape you have drawn.

(4 marks)

3 (e) Hydrogen sulphide,  $H_2S$ , reacts with boron trifluoride,  $BF_3$ , to form compound A.



Predict the value of the H-S-H bond angle in compound A.

......(1 mark)

4	(a)	your answer.	
		Aton	n with larger atomic radius
		Expl	anation
			(4 marks)
4	(b)	(i)	Give the electron arrangement of the sodium atom.
4	(b)	(ii)	State which has the larger radius, a sodium atom or a sodium ion (Na <sup>+</sup> ). Explain your answer.
			Larger radius
			Explanation
			*
4	(b)	(iii)	Suggest why a chloride ion (Cl <sup>-</sup> ) has a larger radius than a chlorine atom.
	` /	` /	
			(5 marks)
4	(c)	Con	sider the sulphates and the hydroxides of the Group II elements Mg to Ba
4	(c)	(i)	Give the formula of the <b>least</b> soluble sulphate
4	(c)	(ii)	Give the formula of the <b>most</b> soluble hydroxide
			(2 marks)

#### **SECTION B**

Answer **both** questions in the space provided on pages 11-16.

5 Diamond and graphite are both giant covalent (macromolecular) forms of carbon.

State how the structures of diamond and graphite are different. Briefly explain why diamond is very hard, and why graphite is able to act as a lubricant and as an electrical conductor.

(7 marks)

**6** On heating, a mixture of sodium and iodine react to form sodium iodide as shown by the equation below.

$$2Na + I_2 \longrightarrow 2NaI$$

The melting points of iodine and sodium iodide are 114 °C and 662 °C respectively.

For each of the substances sodium, iodine and sodium iodide, state the type of bonding present and explain the nature of the attractive forces holding each solid together.

Briefly explain why the melting point of iodine is much lower than that of sodium iodide.

Explain, in terms of electrons, how the reaction between sodium and iodine occurs.

END OF OUESTIONS

(8 marks)

END	Or	QUESTIONS	

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