Section A

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

A1 Table A1.1 shows the most common oxidation states of some elements **A**, **B**, **C**, **D** and **E**.

element	most common oxidation states
A	+1
B	+2
C	-1
D	-2
E	+4

Table A1.1

Use the letter(s) to answer the following questions.

(a) Which element has a giant molecular structure?

_____ [1]

(b) Which elements consist of molecules?

_____ [1]

(c) Which elements conduct electricity in both solid and liquid states?

_____ [1]

(d) What are the chemical formulae of the **oxides** of **B** and **C?**

formula of oxide of **B** _____

formula of oxide of **C** _____ [2]

(e) No element from Group 0 appear in the table.
Use the information in the table to explain why this is true.

_____

_____ [2]

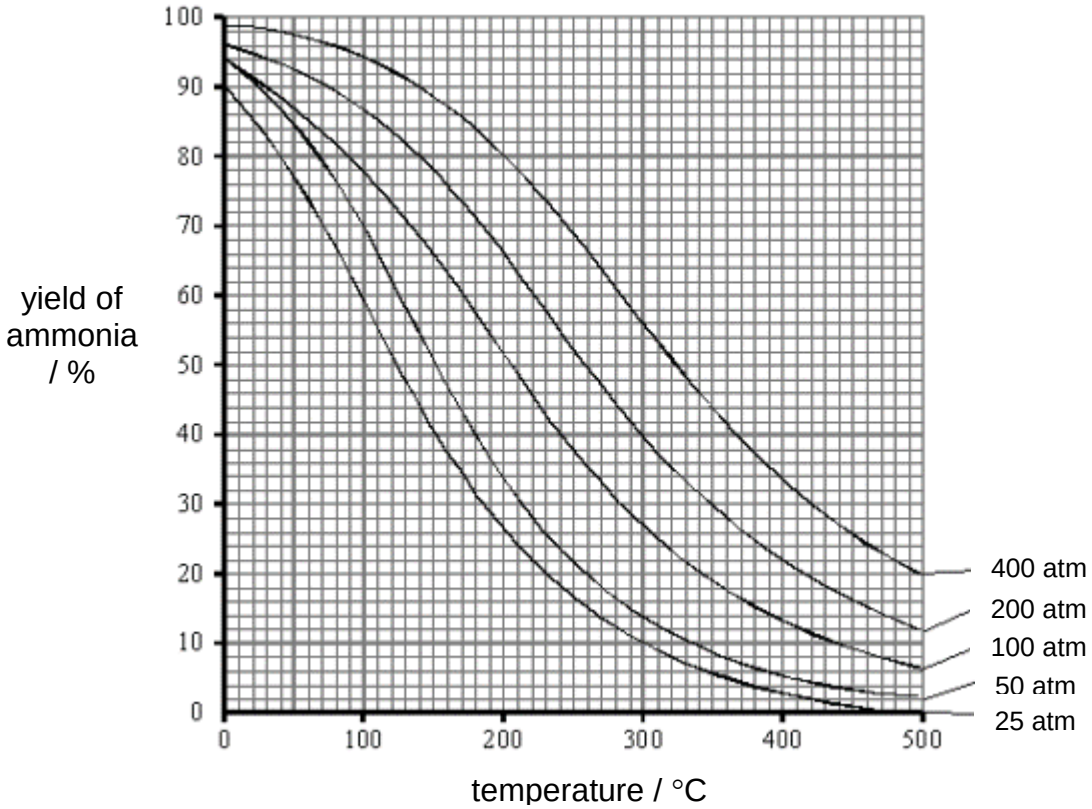
(f) Draw the dot and cross diagram to show the bonding in the compound formed between the following elements. Show only the outer electrons.

(i) **B** and **C** [1]

(ii) **D** and **E** [2]

[Total: 10]

A2 Graph A2.1 shows the percentage yield of ammonia in the equilibrium mixture under different temperature and pressure conditions.



Graph A2.1

(a) In an industrial Haber process, the operating conditions are at a temperature of 450°C and a pressure of 200 atm.
With reference to the graph, state the percentage yield of ammonia under such operating conditions.

[1]

(b) In industrial Haber process, the yield of ammonia is never 100%.
Suggest a reason why.

[1]

(c) It has been stated that, 'the use of 450°C is a compromise between the equilibrium **yield** of ammonia and the **rate of reaction**'.
Explain this statement.

[2]

(d) The ammonia is separated as a liquid from the unreacted gases.
Apart from cost, suggest **two** other reasons why the unreacted gases are recycled.

[2]

(e) Calculate the mass, in tonnes, of ammonia which can be produced from 90 tonnes of hydrogen when the percentage yield is 50%.
[1 tonne = 1000 kg]

[3]

[Total: 9]

A3 Table A3.1 shows some data about the names, structural formulae and enthalpy change of combustion of aldehydes.

name of aldehydes	**structural formula**	**boiling point / °C**	**enthalpy change of combustion (kJ/mol)**
methanal	HCHO	-19.0	-571
ethanal	CH_3CHO	20.2	-1170
		48.8	-1820
butanal	$CH_3CH_2CH_2CHO$	74.8	-2480

Table A3.1

(a) Use two pieces of evidence in the table to explain why aldehydes are a homologous series.

_____

_____ [2]

(b) Give the **name** and **structural formula** of the third member of this homologous series.

name _____

structural formula

[2]

(c) Calculate the enthalpy change of combustion when 1 g of methanal burns.
Show your working.

[2]

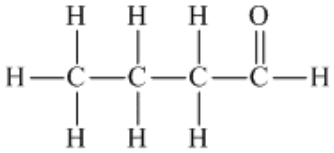
(d) The enthalpy change of combustion in kJ/mol increases from methanal to butanal.
Explain why.

_____

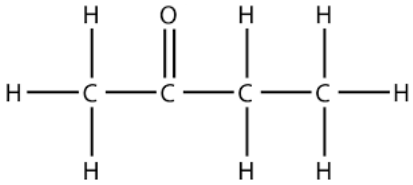
_____

_____ [2]

(e) Butanone is an isomer of butanal.



butanal



butanone

The enthalpy change of combustion of butanone is same as that for butanal.
Suggest why the enthalpy of combustion for the two isomers are the same.

_____

_____

_____ [2]

[Total: 10]

A4 Jane carried out a series of experiments according to the following procedure:

- She added excess magnesium powder in 25 cm^3 of various aqueous salt solutions with the same concentration.
- She calculated the maximum temperature rise in each experiment.

She tabulated the results obtained as shown in Table A4.1 below.

experiment	solution	maximum temperature rise / °C
1	copper(II) sulfate	42
2	lead(II) nitrate	32
3	sulfuric acid	38
4	zinc sulfate	14
5	calcium chloride	0
6	sodium nitrate	0

Table A4.1

(a) State the type of energy change that occurred in experiment 1 to 4.
Explain your answer.

_____

_____

_____ [2]

(b) **(i)** How does the temperature rise relate to the difference in reactivity of magnesium and the metal?

_____

_____ [1]

(ii) Predict the temperature rise when she added excess magnesium powder to 25 cm^3 of iron(II) sulfate of the same concentration.
Explain your reasoning.

temperature rise _____ °C
reason

_____

_____ [2]

(iii) Write an ionic equation for the reaction in **(b)(ii).**

_____ [1]

(c) Explain why there is no rise in temperature for experiment 5 and 6.

_____

_____

_____ [2]

(d) Predict the temperature rise when she added excess magnesium powder to to 25 cm^3 of hydrochloric acid of the same concentration.
Explain your reasoning.

temperature rise _____ °C
reason

_____

_____

_____ [3]

[Total: 11]

A5 Two steel corrosion prevention methods are **anodic protection** and **cathodic protection**.

Anodic protection involves the coating of steel with a less reactive metal such as tin while cathodic protection attaches blocks of a more reactive metal such as zinc on certain parts of a steel body.

(a) State the role of steel as the **anode** or **cathode** in either of the protection methods used

	steel
anodic protection	
cathodic protection	

[1]

(b) Cathodic protection is used in underground steel pipes and ships hulls. Explain how cathodic protection stops the steel from rusting.

_____

_____

_____ [2]

(c) **(i)** Anodic protection is generally applied to steel storage tanks used to store very corrosive liquids such as sulfuric acid.
Suggest how anodic protection stops such steel tanks from rusting.

_____

_____ [1]

(ii) Suggest why cathodic protection is **not** suitable as a rust prevention method for these storage tanks.

_____

_____ [1]

(iii) If the copper coating is scratched, it would bring about faster than expected corrosion of the steel tank.
Explain why.

_____

_____ [1]

[Total: 6]

A6 Table A6.1 shows the names and formulae of some salts and the names of some other compounds used to make them.

Complete the table by filling in the missing information.

name of salt	**formula of salt**	**names of compounds used to make salt**
silver nitrate	$AgNO_3$	_____ and _____
potassium ethanoate	CH_3COOK	potassium hydroxide and _____
ammonium sulfate		sulfuric acid and _____
zinc carbonate	$ZnCO_3$	_____ and _____

Table A6.1

[Total: 4]

Section B: Free Response Questions [30 marks]

Answer all **three** questions in this section.

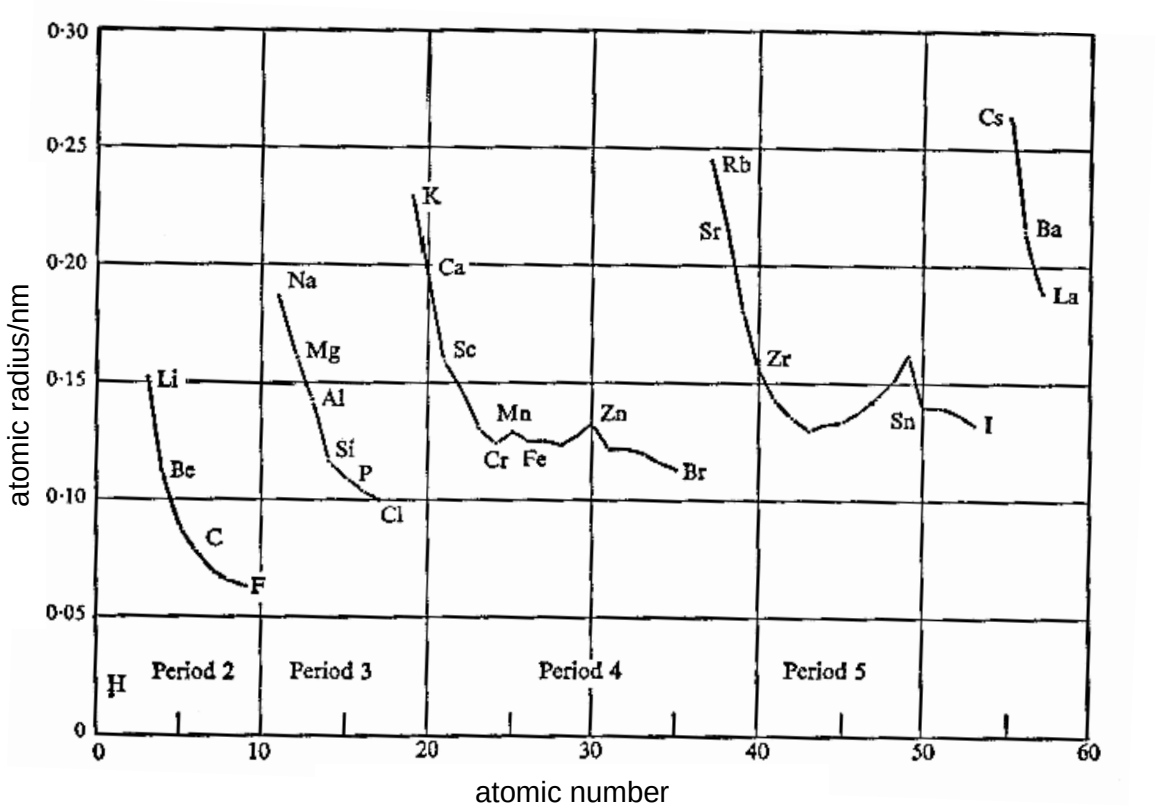
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 The First Periodic Table

In 1869, a Russian chemist, Dmitri Mendeleev, was the first scientist to devise a Periodic Table as shown in Fig. B7.1. He arranged the elements known at the time in order of relative atomic mass. He realised that by arranging the elements in this order, certain types of element occurred regularly, for example a reactive non-metal was directly followed by a very reactive light metal, then a less reactive light metal.

			Ti 50	Zr.... 90	? 180
			V.....51	Nb... 94	Ta ...182
			Cr 52	Mo .. 96	W....186
			Mn.....55	Rh...104.4	Pt....197.4
			Fe 56	Ru ..104.4	Ir....198
			Ni, Co..59	Pd...106.6	Os...199
H.....1			Cu.....63.4	Ag...108	Hg..200
	Be.... 9.4	Mg ...24	Zn.....65.2	Cd...112	
	B.....11	Al.....27.4	? 68	Ur...116	Au ..197
	C.....12	Si.....28	? 70	Sn ...118	
	N.....14	P.....31	As..... 75	Sb...122	Bi....210
	O.....16	S.....32	Se 79.4	Te....128?	
	F.....19	Cl....35.5	Br.....80	J. 127	
	Na.....23	K.....39	Rb.....85.4	Cs...133	Tl....204
		Ca....40	Sr.....87.6	Ba...137	Pb...207
		? 45	Ce 92		
		? Er ..56	La 94		
		? Y ..60	Di.....95		
		? In...75.6	Th.....118		

Fig. B7.1



Graph B7.2

In the modern Periodic Table, the properties of the elements are a function of their atomic numbers. Graph B7.2 gives a series of curves when the atomic radii of elements in successive periods are plotted against the atomic numbers.

The radius of an atom is determined mainly by two factors. One factor is the attraction between the positively charged nucleus and the electrons. The second factor is the 'screening' of the outer electrons from the nucleus by electrons in the inner shells. This screening effect is caused by the mutual repulsion between the electrons in the inner shells and those in outer shells.

(a) Describe three differences between Mendeleev's Periodic Table and the modern Periodic Table.

[3]

(b) What is the current symbol of the element on the modern Periodic Table which is represented by **J** on Mendeleev's?

[1]

(c) With reference to Mendeleev's Periodic Table, give one example of 'a reactive non-metal followed by a reactive light metal then a less reactive light metal'.

[1]

(d) Describe the trend in atomic radii across period 2 and 3.
With reference to the information given above, explain the trend.

[3]

(e) A student makes the following statement on atomic radii.

'The reactivity of Group I metals and halogens is closely related to the trend of atomic radii for these elements.'

Do you support her statement? Explain your reasoning.

[3]

(f) In period 4 and subsequent periods, the trend in atomic radii is interrupted by certain elements. What are these elements?

[1]

[Total:12]

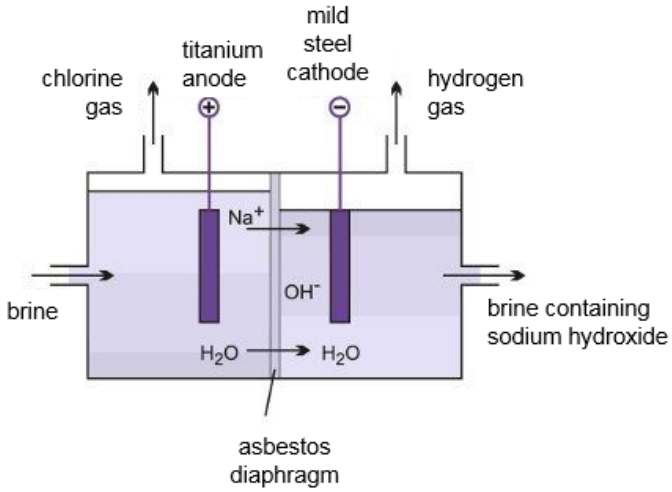
B8 Most chlorine is generated in large amounts by industrial electrolysis of brine, using two basic types of cell: **diaphragm** and **membrane**. A useful by-product sodium hydroxide is also produced in the process.

Brine is a saturated solution of sodium chloride.

The diaphragm and membrane cells are designed so that the products are kept separate. Both cells operate at similar voltages.

If chlorine comes into contact with hydrogen, it produces a mixture which will explode violently on exposure to sunlight or heat. Hydrogen chloride gas would be produced. In addition, chlorine also reacts with sodium hydroxide to produce a mixture of sodium chloride, sodium chlorate(I), NaOC*l* and water.

Fig. B8.1 and B8.2 show the basic operations of these cells.

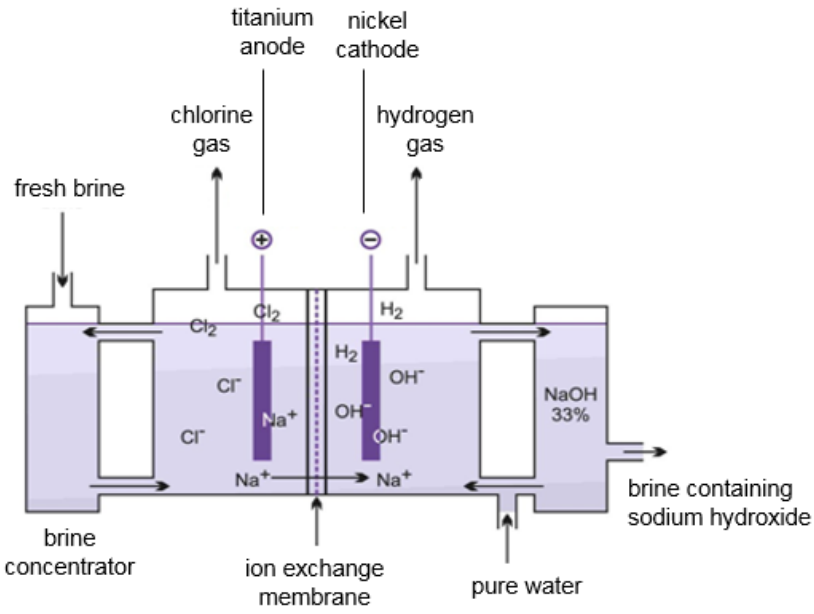


The asbestos diaphragm allows only solution to pass through but not gases.

A higher level of solution is maintained at the anode compartment.

Sodium hydroxide is highly contaminated with sodium chloride solution. It is concentrated by heating. During this process, most of the sodium chloride crystallises out as solid salt.

Fig. B8.1 – diaphragm cell



The ion-exchange polymer membrane only allows positively-charged cations to flow through it.

A high concentration of sodium hydroxide, 33%, is obtained.

Fig. B8.2 – membrane cell

(a) **(i)** In both diaphragm and membrane cells, chlorine is always contaminated with one type of gas.
Name this gas. Write the ionic half equation for its formation.

_____

_____ [2]

(ii) Describe the confirmatory test for chlorine gas.

_____

_____ [1]

(b) Carbon dioxide emissions are higher for diaphragm than membrane cell. Explain why.

_____

_____ [1]

(c) Explain how both diaphragm and membrane cells keep chlorine separate from sodium hydroxide.

_____

_____

_____

_____ [2]

(d) Disproportionation happens when the oxidation state of the same element increases and decreases in the reaction. The overall equation for the above cells is

$$Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$$

Explain why the reaction of chlorine and sodium hydroxide is a disproportionation reaction.

_____

_____

_____ [2]

[Total: 8]

B9 *Either*

Table B9.1 gives the structures of five organic compounds, **A**, **B**, **C**, **D** and **E**.

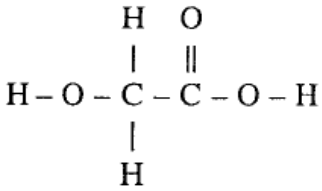
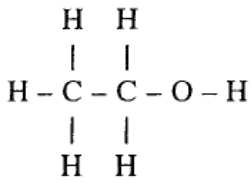
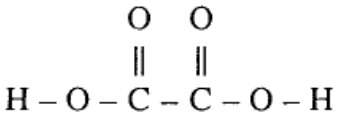
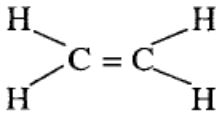
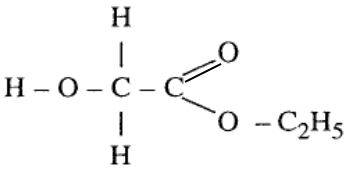
organic compound	structure
A	
B	
C	
D	
E	

Table B9.1

He carried the following tests on four organic compounds **A**, **B**, **C** and **D** by using the following three reagents and separate fresh samples of each organic compound.

- aqueous bromine
- aqueous sodium carbonate
- acidified potassium manganate(VII) and then warm the mixture

(a) **(i)** Describe what the student would **observe** when he adds each of the three reagents to separate fresh samples of **A**, **B**, **C** and **D**.

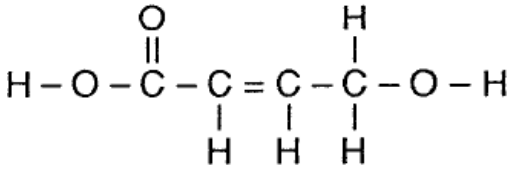
[4]

(ii) Two organic compounds were warmed in the presence of concentrated sulfuric acid to produce compound **E**.
Draw the **displayed formula** of the two compounds used.

compound 1: compound 2:

[2]

(b) An organic compound **X** has the following structural formula:



(i) Draw the repeat unit of the polymer produced when **X** undergoes addition polymerisation.

[1]

(ii) During the addition polymerisation process, the chain length of the polymer is controlled so that the polymer molecules have an average relative molecular mass in the range of 49 000 to 60 000.

What is the range of the average number of repeat units in the polymer molecules?
Show your working.

[2]

(iii) Draw the repeat unit of the polymer produced when **X** undergoes condensation polymerisation.

[1]

[Total: 10]

B9 *OR*

(a) Table B9.2 below shows the composition of gases in a car exhaust under different engine operating conditions.

engine condition	**volume percentage of gases/ %**	
	oxides of nitrogen	**carbon monoxide**
engine idling	0.005	8.000
car cruising	0.300	4.000

Table B9.2

(i) Explain the differences in percentage by volume of oxides of nitrogen and carbon monoxide when the engine is idling and when the car is cruising.

[3]

(ii) In a car catalytic converter, nitrogen monoxide and carbon monoxide react very quickly to produce less polluting gases at a temperature of 700°C.

Explain, in terms of the collision theory,

- how the catalyst speeds up the reaction and
- why the reaction is fast at 700°C.

[3]

(iii) Without conversion in the catalytic converter, the exhaust gases would cause harm to the environment. Explain why.

_____

_____

_____ [2]

(b) A sample of the polluted air can be treated for sulfur dioxide by bubbling it through acidified potassium dichromate(VI). The ionic equation is given below:

$3SO_2\ (g) + Cr_2O_7^{2-}\ (aq) + 2H^+\ (aq) \rightarrow 3SO_4^{2-}\ (aq) + 2Cr^{3+}\ (aq) + H_2O\ (l)$

A solution contains 0.100 mol/dm^3 of dichromate(VI) ions. Given that a 2.00 dm^3 sample of polluted air contains 3.4% by volume of sulfur dioxide measured at room temperature and pressure, calculate the minimum volume of this solution required to remove sulfur dioxide.

[2]

[Total: 10]

***********************End of Paper***

End of FHSS 2018 Prelim P1 and P2