2009Section A

Answer the following question on writing paper.

1 **(a)** One of the most common uses of alkanes is to burn them in air in the internal combustion engine. Alkanes containing between 8 and 12 carbon atoms per molecule are preferred for this.

Draw ***three*** possible structural formulae for the hydrocarbon with lecular formula C_8H_{18}. Include in your answers the structure with the highest boiling point, and the structure with the lowest boiling point.
Give reasons for your choice of structures. **[5]**

(b) **(i)** Write a balanced equation for the complete combustion octane, C_8H_{18}, and hence calculate the volume of air (at room temperature and pressure) needed to burn 57g octane. [Assume air contains 20% oxygen by vo ume.]

(ii) In a separate experiment, a mixture of octane and brom was exposed to UV light. State and explain what you would observe. **[5]**

(c) Ethane, C_2H_6, is another member of the alkane series.
Explain how the boiling points of the following compounds will compare with that of ethane.

(i) chloroethane, C_2H_5Cl **[5]**
(ii) any isomer of C_8H_{18}.

(d) Ethanol, C_2H_5OH, is a colourless water-soluble alcohol. Draw a diagram to illustrate clearly the interaction between C_2H_5OH and H_2O molecules. **[2]**

(e) **(i)** The ethene molecule, C_2H_4, is said to be planar.
The two carbon atoms of ethene can be described as bei g joined by a *s-bond* and a *p-bond*. Briefly explain the terms in *italics*, using diagrams where appropriate.

(ii) Give the numbers of σ and π bonds present in the ethene molecule. **[3]**

[20 marks]

Section B

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

2 Beryllium chloride, $BeCl_2$, is a molecular solid with a melting point of 399^oC. When the solid is vapourised, the vapour is found to consist of a mix of gaseous molecules of $BeCl_2$ and Be_2Cl_4.

(a) **(i)** Draw a dot-and-cross diagram to show the electronic structure of a molecule of $BeCl_2$.

(ii) Suggest how you would expect Be_2Cl_4 to form from $BeCl_2$.

(iii) Draw a diagram to show the types of bonds present in the Be_2Cl_4 molecule. Give a value for each of the Cl-Be-Cl and Be-Cl-Be bond angles.

∠Cl-Be-Cl =

∠Be-Cl-Be = **[6]**

(b) Ions of $BeCl_2$ and Be_2Cl_4 can be obtained by passing the vapour through a plasma torch.

The following equations show some of the ions formed.

$$BeCl_2 \rightarrow BeCl_2^+ + e$$
$$Be_2Cl_4 \rightarrow Be_2Cl_4^+ + e$$

Figure 1 below shows the pathway of $Be_2Cl_4^+$ in an electric field.

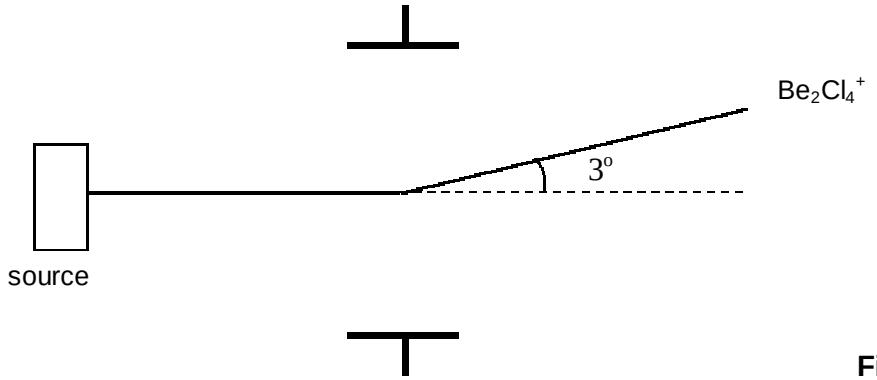


Figure 1

(i) Suggest why energy is required to convert the Be_2Cl_4 molecule to its corresponding $Be_2Cl_4^+$ ion.

(ii) Indicate the polarity (+ or -) of both plates in Figure 1.

(iii) In Figure1, draw and label the pathway of the $BeCl_2^+$ ion. Explain the position of this pathway.

[4]

[10 marks]

3 (a) Explain the terms *rate equation*, *order of reaction* and *rate constant*.

[3]

(b) In an experiment, bromine reacts with an ester slowly enough for the reaction to be followed by usual laboratory techniques. The following ts were obtained at 25°C.

Experiment number	Initial conc of ester / mol dm^{-3}	Initial conc of Br_2 / mol dm^{-3}	Initial rate of reaction / mol dm^{-3} s^{-1}
1	2.0×10^{-2}	2.0×10^{-2}	6.51×10^{-4}
2	4.0×10^{-2}	2.0×10^{-2}	1.29×10^{-3}
3	6.0×10^{-2}	2.0×10^{-2}	1.94×10^{-3}
4	2.0×10^{-2}	4.0×10^{-2}	2.55×10^{-3}
5	2.0×10^{-2}	6.0×10^{-2}	

(i) Deduce the order of reaction with respect to the ester and bromine respectively. Show clearly how you obtain your answer.

ester

bromine

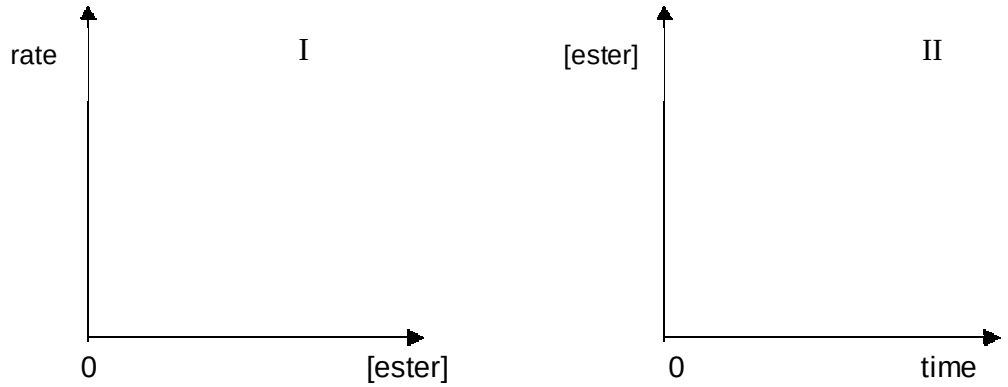
(ii) Predict the initial rate of reaction in Expt 5 and complete the box above.

(iii) Write the rate equation for the reaction.

(iv) By what factor will the rate increase if the concentrations of the ester and bromine are **both** doubled?

(v) In an experiment in which bromine is used in large excess, sketch on the axes below to show how

I the rate of reaction varies with [ester]
II [ester] varies with time



[9]

(c) Explain briefly how the initial reaction rate would be expected to change by increasing the temperature.

[2]
[14 marks]

4 **(a)** Sodium peroxide, Na_2O_2, is used in submarines for absorbing atmospheric carbon dioxide and regenerating oxygen. The reaction produces sodium carbonate as a by-product.

(i) Write a balanced equation for this reaction.

(ii) Calculate the mass of sodium peroxide needed per day to absorb the carbon dioxide produced by a crew of six submariners, each of whom exhales 500 dm^3 of CO_2 per day.
[All volumes are measured at room temperature and pressure.]

[3]

(b) In a laboratory experiment, 1.54 g of carbon dioxide are produced and then absorbed in 50.0 cm^3 of a sodium hydroxide solution forming sodium carbonate.

(i) Write a balanced equation for this reaction.

(ii) Calculate the molar concentration of the sodium carbonate in the solution.

[3]
[6 marks]

Section C

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the one you consider to be correct.

1 The value of the Avogadro Constant L is 6.0×10^{23} mol^{-1}. The mass, in g, of one molecule of propane (RMM = 44) is therefore

A $44.0 \times 6.0 \times 10^{23}$

B $\dfrac{6.0 \times 10^{23}}{44}$

C $\dfrac{44}{6.0 \times 10^{23}}$

D $\dfrac{1}{44 \times 6.0 \times 10^{23}}$

2 Which statement about a 24 g of Mg is always correct?

A It contains the same number of atoms as 71 g of chlorine gas.
B It contains the same number of moles as 24 dm^3 of neon gas at r.t.p.
C It contains the same number of moles as 1/12 g of C.
D It is liberated by 1 mole of electrons.

3 A sample of 2.00g of iron(III) sulphate, $Fe_2(SO_4)_3$, is dissolved in water to give 100 cm^3 of aqueous solution. What is the concentration of SO_4^{2-} ions?

A 5.0×10^{-3} mol dm^{-3}
B 1.5×10^{-3} mol dm^{-3}
C 5.0×10^{-2} mol dm^{-3}
D 1.5×10^{-1} mol dm^{-3}

4 If 1.5 dm^3 of a 2.00 mol dm^{-3} solution and a 2.5 dm^3 of a 0.60 mol dm^{-3} solution of the same substance were mixed, what would the concentration of substance in the resulting solution be?

A 1.54 mol dm^{-3}
B 1.13 mol dm^{-3}
C 0.87 mol dm^{-3}
D 0.65 mol dm^{-3}

5 In a titration 30 cm^3 of 0.05 mol dm^{-3} phosphoric acid was found to react exactly with 15 cm^3 of 0.20 mol dm^{-3} aqueous sodium hydroxide.
The equation for the reaction occurring is

A $NaOH + H_3PO_4 \rightarrow NaH_2PO_4 + H_2O$
B $2NaOH + H_3PO_4 \rightarrow Na_2HPO_4 + 2H_2O$
C $3NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3H_2O$
D $NaOH + H_3PO_4 \rightarrow NaPO_3 + 2H_2O$

6 Which one of the following is **not** a redox reaction?

A $2Al + 3Cl_2$? $2AlCl_3$
B $SnCl_2 + HgCl_2$? $Hg + SnCl_4$
C $2CrO_4^{2-} + 2H^+$? $Cr_2O_7^{2-} + H_2O$
D $Cu_2O + H_2SO_4$? $CuSO_4 + Cu + H_2O$

7 When ammonia is converted into nitric acid on a commercial scale, the following reactions can occur. In which reaction does the greatest change n oxidation number of nitrogen occur?

A $4NH_3 + 5O_2$? $4NO + 6H_2O$
B $3NO_2 + H_2O$? $2HNO_3 + NO$
C $2NO + O_2$? $2NO_2$
D $4NH_3 + 6NO$? $5N_2 + 6H_2O$

8 When dilute acid is added to an aqueous solution containing manganate ions and hydrogen peroxide, oxygen gas is evolved.

$$2MnO_4^- + 5H_2O_2 + 6H^+ \text{ ? } 2Mn^{2+} + 8H_2O + 5O_2$$

Which one of the following statements about this reaction is **true**?

A Hydrogen ions act as a catalyst.
B Hydrogen peroxide acts as a reducing agent.
C Hydrogen ions are oxidised to water.
D The oxidation number of manganese changes by 6.

9 A sample of 10.0 cm^3 of 0.10 mol dm^{-3} iron(II) sulphate is titrated against 0.025 mol dm^{-3} potassium manganate(VII) in the presence of an excess f fluoride ions. It is found that 10.0 cm^3 of the managante(VII) solution is required to reach the end-point.

What is the oxidation number of the manganese at the end-point?

A +2 **B** +3 **C** +4 **D** +5

10 *The use of the Data Booklet is relevant to this question.*
The successive ionization energies, in kJ mol^{-1}, of an element X are given below

870 1800 3000 3600 5800 7000 13200

What is X?

A $_8O$ **B** $_{33}As$ **C** $_{40}Zr$ **D** $_{52}Te$

11 Which one of the following equations relates to the first ionization energy of nitrogen?

A $N_2(g)$ à $2N^+(g) + 2e^-$
B $\frac{1}{2}N_2(g)$ à $N^+(g) + e^-$
C $N(g) + e^-$ à $N^-(g)$
D $N(g)$ à $N^+(g) + e^-$

12 Which one of the following corresponds to the configuration of the three electrons of highest energy for the ground state of an element in Group III?

A $1s^2\ 2s^1$ **C** $2s^1\ 2p^2$
B $2s^2\ 2p^1$ **D** $3p^3$

13 What is the proton (atomic) number of an element that has four unpaired electrons in its ground-state?

A 14 **B** 16 **C** 22 **D** 26

14 Carbon-14 is radioactive and is used by archaeologists in carbon dating.
Which species has both the same number of neutrons and the same of electrons as an atom of carbon-14?

A $^{14}N^+$ **B** $^{15}O^{2-}$ **C** $^{16}O^{2+}$ **D** ^{23}Na

15 The shapes of three species **P**, **Q** and **R** are respectively bent, square planar and trigonal pyramidal. Which of the following can be P, Q and R?

	P	**Q**	**R**
A	F_2O	CH_4	BCl_3
B	CS_2	BH_4^-	SF_6
C	$SnCl_2$	BrF_4^-	SbF_3
D	CH_4	H_2S	SO_3^{2-}

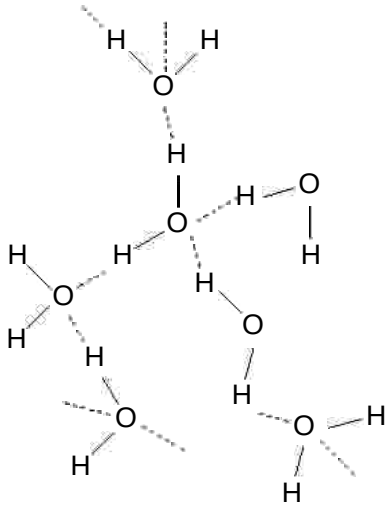
16 A solid **X** has the following physical properties.

It is insoluble in water.
Its melting point is 1290°C.
It conducts electricity in both solid and molten state.

Which of the following substances is **X**?

A Fe
B SiO_2
C $CaCl_2$
D Dry ice (solid CO_2)

17 The diagram below shows the structure of part of a crystal of ice.



Which statement is correct?

A All the bonds angles surrounding each oxygen atom are 120°.
B The hydrogen bonds are stronger than the O-H covalent bonds.
C The open structure of ice causes ice to be denser than water.
D Four electrons from each oxygen are involved in forming hydrogen bonds.

18 What structural feature is common to both diamond and graphite?

A covalent bonds between carbon atoms
B each carbon atom is bonded to four others
C delocalised electrons
D a carbon-carbon bond length equal to that in ethane

19 For a reaction to be zero order with respect to substance **X**, it is necessary that

A there is no other reactant in addition to substance **X**.
B the overall equation for the reaction does not contain substance **X.**
C the overall order of reaction is zero.
D the rate of reaction is not affected by the concentration of substance **X.**

20 A radioactive element has a half-life of 10 minutes. What is the time required for 75% of the mass of the radioactive element to decompose?

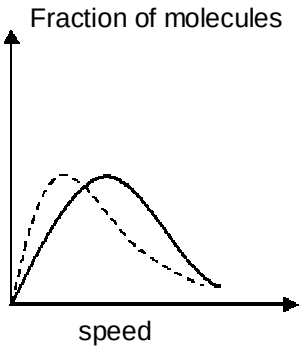
A 15 min **B** 20 min **C** 25 min **D** 30 min

21 Which one of the following correctly represents the units of the rate constant k r a second order reaction?

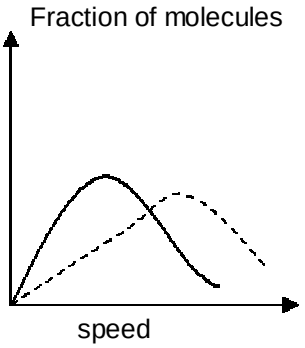
A s^{-1}
B mol dm^{-3}
C mol^{-1} dm^3 s^{-1}
D mol dm^{-3} s^{-1}

22 Which graph most accurately represents the distributio molecular speeds in a gas at 300 K if the dotted curve represents the corresponding distribution for the same gas at 500K?

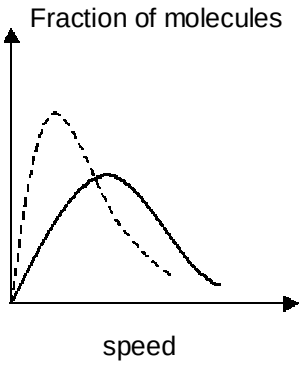
A



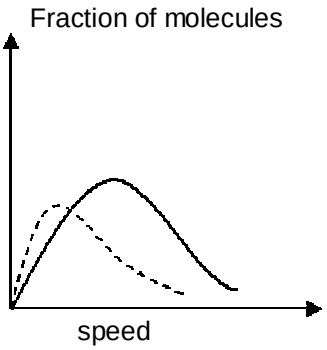
B



C



D



23 100 cm^3 of a hydrocarbon requires 550 cm^3 of oxygen for complete oxidation to carbon dioxide and water. The hydrocarbon is most likely to be

A CH_4 **B** C_2H_4 **C** C_3H_8 **D** C_4H_6

For each of the following questions, one or more of the three numbered statements **1** to **3** may be correct. Decide whether each of the statements is or is not correct. (You may find it helpful to put a tick against the statements which you consider to be correct.) The responses **A** to **D** should be selected on the basis of

A	B	C	D
1,2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

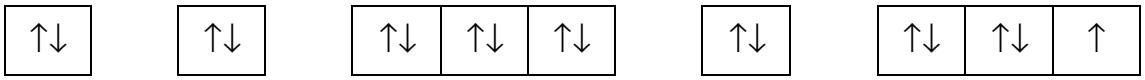
24 Which of the following affect the rate constant of a reaction?

1 Change in concentration

2 Change in temperature

3 Use of a suitable catalyst

25 A species **X** has the following electronic configuration.



What could **X** be?

1 P^{2-} ion

2 Cl atom

3 Ar^{+} ion

26 Which of the following statements about the properties of a catalyst are correct?

A catalyst increases

1 the rate of the reverse reaction.

2 the average kinetic energy of the reacting particles.

3 the amount of products formed

27 Sodium reacts with ammonia to give hydrogen and sodami which is ionic.

$2Na + 2NH_3 \rightarrow 2NaNH_2 + H_2$

What changes in oxidation number of the three elements involved occur?

1 -3 to -2

2 0 to +1

3 +1 to 0

A	B	C	D
1,2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

28 In which sequences are the molecules quoted in order of increasing bond angle within the molecule?

1 H_2O NH_3 CH_4

2 H_2O SF_6 BF_3

3 CH_4 CO_2 SF_6

29 Which statements about the complete combustion of an a ne, C_nH_{2n}, in oxygen are correct?

1 The volume of oxygen required is directly proportional the number of carbon atoms present in the molecule.

2 The volume of gas produced at 25^oC is the same as for the complete combustion of an alkane with the same number of carbon atoms per molecule.

3 At 120^oC, the volume of steam produced is always twice the vo ume of carbon dioxide.

30 Which of the following solids have giant lattices?

1 iodine
2 sodium
3 sodium iodide