Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Tuesday 3 June 2014 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

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 ▶

P42971A

6/6/6/6/3/3/

P 4 2 9 7 1 A 0 1 2 4

PEARSON

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 When sodium is added to ethanol, which of the following observations would be made?

☒ **A** Colour change of orange to green

☒ **B** Effervescence

☒ **C** Yellow flame

☒ **D** No change

(Total for Question 1 = 1 mark)

2 Which of the following substances does **not** have intermolecular hydrogen bonds?

☒ **A** Ethanoic acid, CH_3COOH

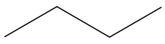
☒ **B** Propanone, CH_3COCH_3

☒ **C** Methanol, CH_3OH

☒ **D** Water, H_2O

(Total for Question 2 = 1 mark)

3 Which of the following molecules has the lowest boiling temperature?



A

Pentane

B

C_3H_6

C

D

☒ **A**

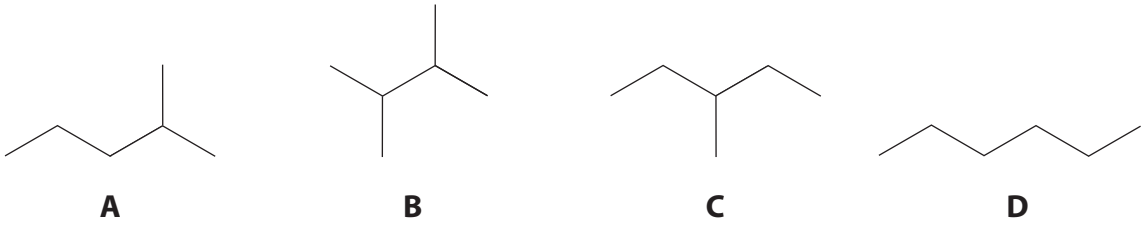
☒ **B**

☒ **C**

☒ **D**

(Total for Question 3 = 1 mark)

4 Which of the following molecules has the highest melting temperature?



A **B** **C** **D**

☒ **A**

☒ **B**

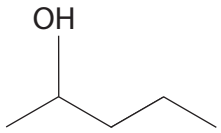
☒ **C**

☒ **D**

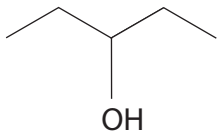
(Total for Question 4 = 1 mark)

5 Which of the following isomeric alcohols, with molecular formula $C_5H_{12}O$, can be oxidized to a carboxylic acid with five carbon atoms?

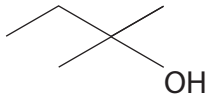
☒ **A**



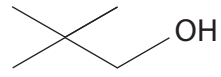
☒ **B**



☒ **C**

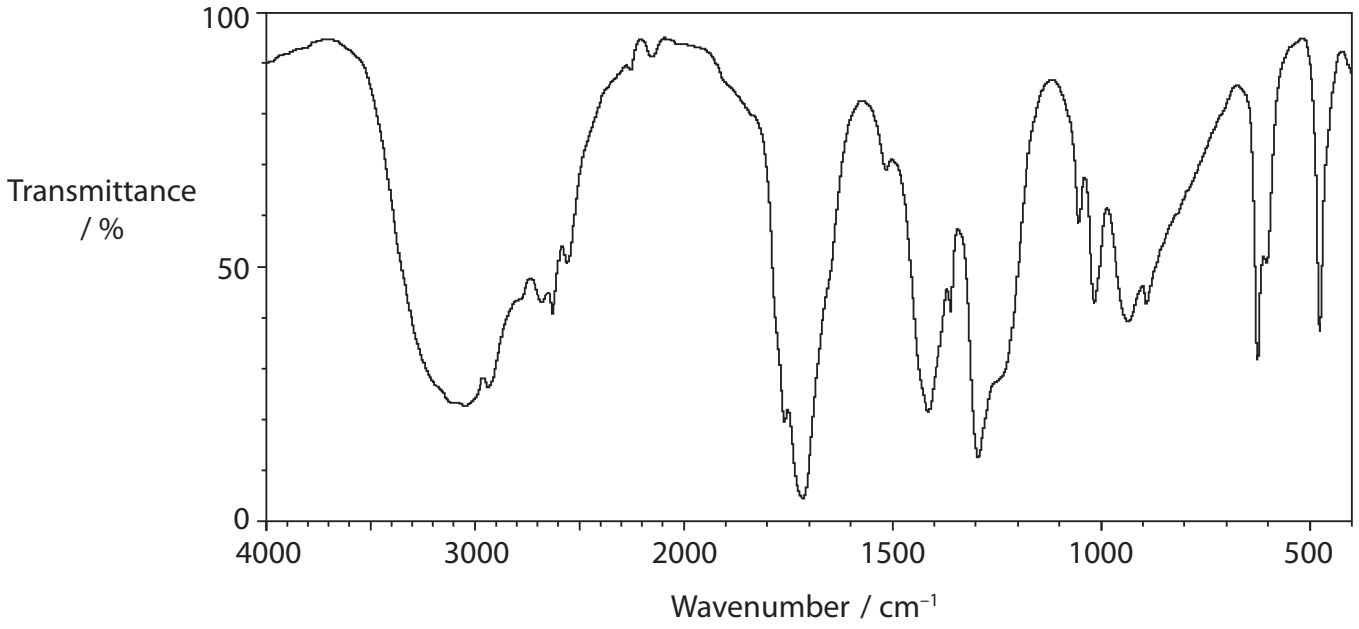


☒ **D**



(Total for Question 5 = 1 mark)

6 Consider the infrared spectrum shown below.



The IR absorption ranges associated with some organic functional groups are given below.

O—H stretching in alcohols (variable, broad)	3750 – 3200 cm^{-1}
O—H stretching in carboxylic acids (weak)	3300 – 2500 cm^{-1}
C═O stretching in aldehydes (strong)	1740 – 1720 cm^{-1}
C═O stretching in ketones (strong)	1700 – 1680 cm^{-1}
C═O stretching in carboxylic acids, alkyl (strong)	1725 – 1700 cm^{-1}
C—H stretching in aldehydes (weak)	2900 – 2820 cm^{-1} and 2775 – 2700 cm^{-1}

Which of the following could have produced the above spectrum?

☒ **A** An aldehyde

☒ **B** An alcohol

☒ **C** A carboxylic acid

☒ **D** A ketone

(Total for Question 6 = 1 mark)

7 In a mass spectrum of butane, C_4H_{10}, where would a peak be seen for the molecular ion if it had a charge of 2+?

☒ **A** 29

☒ **B** 56

☒ **C** 58

☒ **D** 60

(Total for Question 7 = 1 mark)

8 When a flame test is carried out on calcium iodide, the colour of the flame is

☒ **A** yellow-red.

☒ **B** pale green.

☒ **C** purple.

☒ **D** crimson.

(Total for Question 8 = 1 mark)

9 The indicator methyl orange is a weak acid and may be represented by the formula HA(aq). The equation for its dissociation is shown below.

$$HA(aq) \rightleftharpoons A^-(aq) + H^+(aq)$$

Colour: Red Yellow

Under certain conditions, at equilibrium, a solution of HA has a yellow colour. On addition of a small volume of dilute sodium hydroxide, the colour of this solution would

☒ **A** change from yellow to red.

☒ **B** change from yellow to orange.

☒ **C** change from yellow to orange and then to red.

☒ **D** not change.

(Total for Question 9 = 1 mark)

10 Consider the following Group 2 compounds.

Group 2 hydroxides	Group 2 sulfates
$Mg(OH)_2$	$MgSO_4$
$Ca(OH)_2$	$CaSO_4$
$Sr(OH)_2$	$SrSO_4$

The solubility

☒ **A** increases down the group for both hydroxides and sulfates.

☒ **B** increases down the group for hydroxides but increases up the group for sulfates.

☒ **C** increases up the group for hydroxides but increases down the group for sulfates.

☒ **D** increases up the group for both hydroxides and sulfates.

(Total for Question 10 = 1 mark)

11 Which of the following is the correct equation for the decomposition of the corresponding nitrate?

☒ **A** $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$

☒ **B** $4NaNO_3 \rightarrow 2Na_2O + 4NO_2 + O_2$

☒ **C** $Mg(NO_3)_2 \rightarrow Mg(NO_2)_2 + O_2$

☒ **D** $Ba(NO_3)_2 \rightarrow Ba(NO_2)_2 + O_2$

(Total for Question 11 = 1 mark)

12 What is the oxidation number of phosphorus in P_4O_6?

☒ **A** +3

☒ **B** +4

☒ **C** +5

☒ **D** +6

(Total for Question 12 = 1 mark)

13 For barium, the third ionization energy is higher than the second ionization energy because

☒ **A** there is an increase in the number of protons.

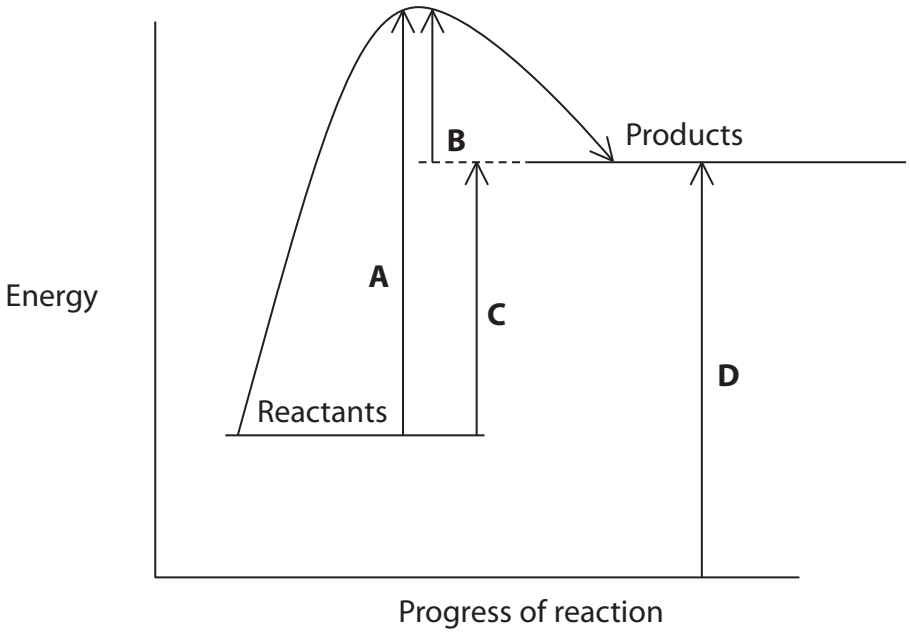
☒ **B** there is an increase in the shielding.

☒ **C** the ionic radius is greater.

☒ **D** the electron being removed is closer to the nucleus.

(Total for Question 13 = 1 mark)

14 The reaction profile for an endothermic reaction is shown below.



(a) Which arrow represents the activation energy for the **forward** reaction?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which arrow represents the activation energy for the **backward** reaction?

(1)

☒ **A**

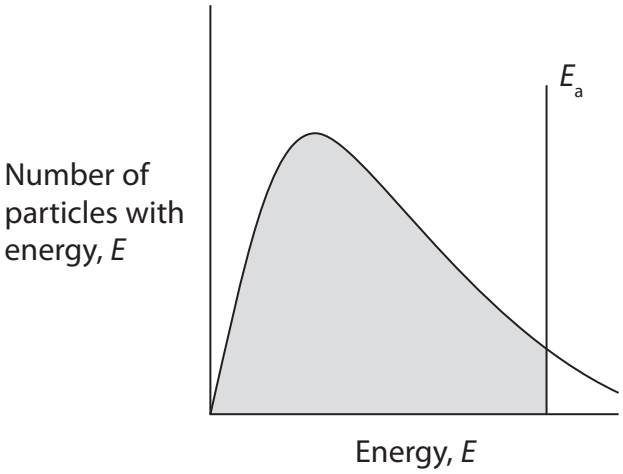
☒ **B**

☒ **C**

☒ **D**

(Total for Question 14 = 2 marks)

15 Consider the Maxwell-Boltzmann distribution of energies for a gas shown below. E_a represents the activation energy.



The shaded area of the diagram indicates the total number of particles that

☒ **A** do have enough energy to react.

☒ **B** do not have enough energy to react.

☒ **C** do have enough energy to react in the presence of a catalyst.

☒ **D** do not have enough energy to react in the presence of a catalyst.

(Total for Question 15 = 1 mark)

16 Which of the following is a pure form of carbon that has both hexagonal and pentagonal rings in its structure and can conduct electricity?

☒ **A** Charcoal

☒ **B** Buckminsterfullerene

☒ **C** Diamond

☒ **D** Graphite

(Total for Question 16 = 1 mark)

17 Hydrogen, H_2, is not a completely 'carbon neutral' fuel. Which of the following is an **incorrect** reason for this?

☒ **A** Some CO_2 is released in the transportation of H_2 fuel.

☒ **B** CO_2 is made when the electricity is generated for the manufacture of H_2.

☒ **C** A small amount of CO_2 is produced on the combustion of H_2 fuel.

☒ **D** CO_2 is released during the construction of the H_2 manufacturing plant.

(Total for Question 17 = 1 mark)

18 When steam is passed over heated magnesium, which of the following occurs?

☒ **A** $Mg + H_2O \rightarrow MgO + H_2$

☒ **B** $Mg + H_2O \rightarrow MgOH + \frac{1}{2}H_2$

☒ **C** $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$

☒ **D** There is no reaction with the magnesium.

(Total for Question 18 = 1 mark)

19 Which of the following will **not** affect the rate of the reaction below?

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

☒ **A** Surface area

☒ **B** Concentration

☒ **C** Pressure

☒ **D** Temperature

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

20 Brand **X** is unlike many conventional toilet cleaners in that it does not contain bleach, but instead contains hydrochloric acid. The label states that the toilet cleaner contains 9 g of HCl per 100 cm^3 of the toilet cleaner.

An industrial technician was given the task of checking the validity of this statement. Using 25.0 cm^3 portions of the toilet cleaner, the technician carried out a titration using 2.50 mol dm^{-3} sodium hydroxide solution and obtained the following results.

Titration	Trial	1	2
Final Volume /cm^3	25.00	49.60	24.50
Initial Volume /cm^3	0.00	25.00	0.00
Volume Added /cm^3			

(a) (i) Complete the table and calculate the mean titre by selecting the appropriate results.

(1)

(ii) Write the equation for the titration reaction. State symbols are not required.

(1)

(iii) Calculate the number of moles of sodium hydroxide that reacted.

(1)

(iv) Hence state the number of moles of hydrochloric acid that reacted with the sodium hydroxide.

(1)

(v) Calculate the mass of HCl present in 100 cm^3 of the toilet cleaner. Give your answer to 3 significant figures.

(2)

(vi) Using the technician's results, comment on the validity of the manufacturer's statement that the toilet cleaner contained 9 g of HCl per 100 cm^3. Justify your answer.

(1)

.....

.....

.....

(vii) Explain why titrations involving the use of a 2.50 mol dm^{-3} sodium hydroxide solution would **not** be advisable in a school or college laboratory.

(1)

.....

.....

(b) Conventional toilet cleaners contain a bleaching agent. Chloric(I) acid, HOCl, is one such substance.

Draw the dot and cross diagram for chloric(I) acid. Show outer electrons only.

(1)

(c) The instructions for the use of Brand **X** state that the toilet cleaner should not be used with bleaching agents.

Complete the equation for the reaction between the hydrochloric acid in the toilet cleaner and the chloric(I) acid in the bleaching agent. Give a reason why this reaction is to be avoided in accordance with the instructions for the use of the toilet cleaner.

(2)

Equation HCl + HOCl →

Reason .....

.....

.....

(d) Another bleaching agent is sodium chlorate(I), NaClO, which can be purchased as a solution. It can also be obtained by bubbling chlorine gas into sodium hydroxide solution.

(i) Give the oxidation numbers of the chlorine-containing species in the equation below and classify the reaction as a result of your answer.

$$2NaOH(aq) + Cl_2(g) \longrightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

Oxidation Number ....

(2)

Type of reaction .....

(ii) State how the reaction conditions would need to be changed in order to produce sodium chlorate(V) instead of sodium chlorate(I).

(1)

.....

.....

(iii) Give the equation for the reaction between chlorine and sodium hydroxide solution that forms sodium chlorate(V) as one of the products. State symbols are not required.

(2)

(Total for Question 20 = 16 marks)

21 This is a question about halogenoalkanes.

(a) Halogenoalkanes can react with hydroxide ions in different ways depending on the conditions used. Using 1-chloro-1-fluoroethane, CH_3CHClF, as an example of a halogenoalkane, the following reaction could occur in aqueous solution.

$$CH_3CHClF + OH^- \rightarrow CH_3CHOHF + Cl^-$$

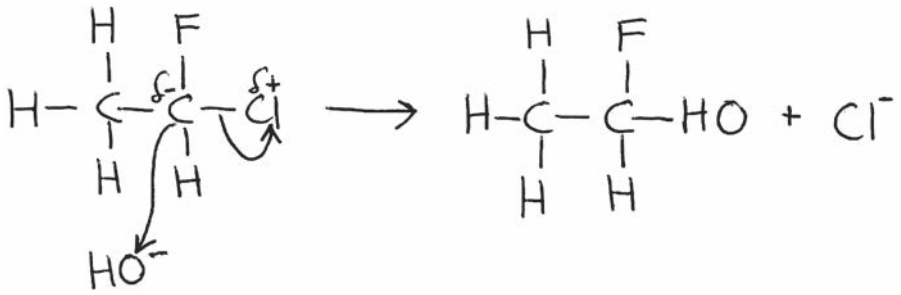
(i) Suggest why it is unlikely that the fluorine atom in CH_3CHClF would be substituted by the hydroxide ion.

(1)

.....

.....

*(ii) A student attempted to draw the reaction mechanism for the reaction in (a)(i), but made a total of three errors.



Identify these errors and state how they should be corrected.

(3)

First error .....

.....

.....

Second error .....

.....

.....

Third error .....

.....

.....

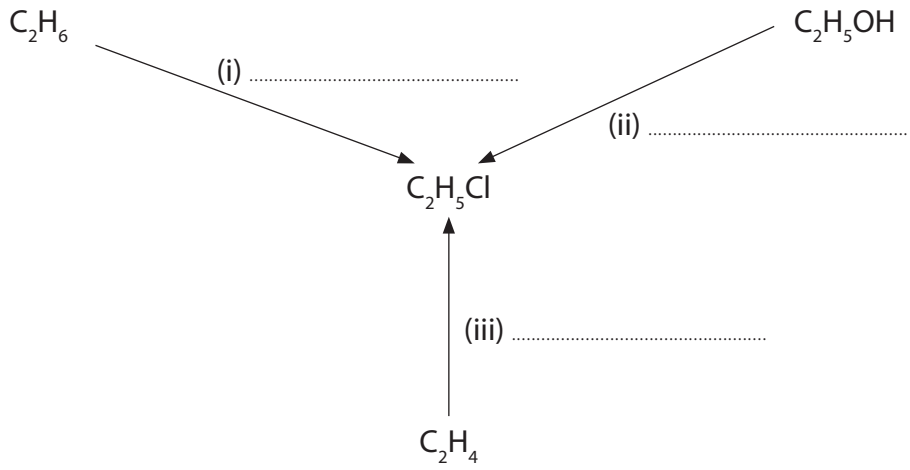
(iii) In hot alcoholic solution, a different reaction may occur between halogenoalkanes and hydroxide ions.

Write the equation for the reaction between 1-chloro-1-fluoroethane, CH_3CHClF, and hydroxide ions in alcoholic solution.

(2)

(b) Chloroethane can be produced in various ways as shown below. Identify, by name or formula, the reagent needed for each of these reactions.

(3)



(c) (i) Chloroethane will react with alcoholic ammonia **initially** to produce ethylamine. Complete the equation for this reaction.

(1)

..... + NH_3 → ..... + ...

(ii) Name the type and mechanism of the reaction occurring in (c)(i).

(2)

.....

.....

(iii) What feature of the ammonia molecule enables the reaction in (c)(i) to take place?

(1)

.....

(iv) If aqueous ammonia was used in (c)(i), instead of alcoholic ammonia, suggest the identity of the organic product that would be formed.

(1)

.....

(d) Dichlorodifluoromethane, CCl_2F_2, is also known as Freon 12 and its manufacture was banned in 1994 under the terms of the Montreal Protocol.

(i) Complete the equation for the initiation stage and suggest equations for two of the propagation stages and a termination stage for the mechanism of the reaction that this molecule might undergo with ozone.

(4)

Initiation $CCl_2F_2 \rightarrow$

Propagation 1

Propagation 2

Termination

*(ii) Explain why the effect of Freon 12 molecules on the ozone layer was such a serious issue that scientists recommended its use to be discontinued.

(2)

.....

.....

.....

.....

(iii) Freon 12, CCl_2F_2, could also be described as a "greenhouse gas". Explain what the term 'greenhouse gas' means.

(2)

.....

.....

.....

.....

(iv) Freon 12, and other similar molecules, are not normally viewed as contributors to the greenhouse effect. Suggest why this is so.

(1)

.....

.....

(Total for Question 21 = 23 marks)

TOTAL FOR SECTION B = 39 MARKS

SECTION C

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

22

Spontaneous combustion is often a subject of fantasy in movies, but it does actually happen with some chemical compounds. One such compound is silane, SiH_4, which is analogous to methane, CH_4. Methane is the main gas that is used in school and college laboratories with Bunsen burners, but it requires a spark or a lighted splint to ignite. Silane does not require any such ignition, and at room temperature is spontaneously flammable. This can make an interesting chemical demonstration.

One method of making silane is by mixing together two solids, silicon dioxide and magnesium, with the magnesium being in excess. The two chemicals are thoroughly mixed together. This mixture is then heated to red-heat and initially produces powdered silicon. The silicon then reacts further with the excess magnesium powder and forms magnesium silicide, Mg_2Si. The two reactions which occur are shown in the equations below.

$$SiO_2 + 2Mg \longrightarrow 2MgO + Si$$

$$Si + 2Mg \longrightarrow Mg_2Si$$

The magnesium silicide formed is then reacted with hydrochloric acid to form silane, SiH_4.

(a) Complete and balance the equation for this reaction. State symbols are not required.

(2)

Mg_2Si + ...HCl ⟶ ..... + ...

(b) Bubbles of silane rise to the surface in the reaction mixture and spontaneously combust with oxygen in the air.

Suggest the names or formulae of the products of the reaction between silane and oxygen.

(2)

.....

.....

(c) Predict the molecular shape of silane, SiH_4, and suggest the bond angle.

(2)

Shape .....

Bond angle .....

(d) Explain why the Si—H bond is longer than the C—H bond.

(2)

*(e) Identify the intermolecular forces present in pure samples of both silane and methane.

Explain why silane has a higher boiling temperature than methane and why both are gases at room temperature.

(4)

(f) (i) Define the term **electronegativity**.

(2)

*(ii) Some Pauling electronegativity values for selected elements are given below.

H 2.1						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0

Using the values in the table above, compare the polarity of the bonds in a molecule of methane with that found in a molecule of silane.

Comment on the significance of any difference.

(3)

(iii) Using the table in (f)(ii), choose an element which, when covalently bonded to hydrogen, forms a molecule containing bonds that are more polar than those in silane or methane. Give the formula of the hydride of your chosen element and state the electronegativity difference.

(2)

(iv) Explain why it is possible for the bonds within a molecule to be polar, but for the molecule itself to be non-polar. Give an example of such a molecule.

(2)

(Total for Question 22 = 21 marks)

TOTAL FOR SECTION C = 21 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