Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Friday 9 June 2017 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or **black** 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 ▶

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6/6/5/6/1/1/

P 4 8 3 8 3 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 Which is the shortest covalent bond?

☒ **A** H—H

☒ **B** H—N

☒ **C** H—S

☒ **D** H—Br

(Total for Question 1 = 1 mark)

2 Which compound contains a bond with the **greatest** polarity?

☒ **A** Ammonia, NH_3

☒ **B** Hydrogen fluoride, HF

☒ **C** Methane, CH_4

☒ **D** Water, H_2O

(Total for Question 2 = 1 mark)

3 Which compound has polar bonds but non-polar molecules?

☒ **A** Carbon monoxide, CO

☒ **B** Hydrogen sulfide, H_2S

☒ **C** Phosphorus(III) chloride, PCl_3

☒ **D** Tetrafluoromethane, CF_4

(Total for Question 3 = 1 mark)

4 Cyclohexane is a non-polar liquid. Therefore

☒ **A** sodium chloride is very soluble in cyclohexane.

☒ **B** cyclohexane conducts electricity.

☒ **C** a jet of cyclohexane is deflected by a charged rod.

☒ **D** cyclohexane forms two layers when mixed with water.

(Total for Question 4 = 1 mark)

5 In which reaction is calcium oxidised?

☒ **A** $Ca + 2HCl \rightarrow CaCl_2 + H_2$

☒ **B** $CaO + 2K \rightarrow Ca + K_2O$

☒ **C** $CaO + H_2O \rightarrow Ca(OH)_2$

☒ **D** $CaCO_3 \rightarrow CaO + CO_2$

(Total for Question 5 = 1 mark)

6 Consider the following ionic half-equations

$$Al \rightarrow Al^{3+} + 3e^-$$

$$2H^+ + 2e^- \rightarrow H_2$$

When these ionic half-equations are combined, the full ionic equation is

☒ **A** $Al + 2H^+ \rightarrow Al^{3+} + H_2$

☒ **B** $Al + 2H^+ + 2e^- \rightarrow Al^{3+} + H_2 + 3e^-$

☒ **C** $Al + 6H^+ \rightarrow Al^{3+} + 3H_2$

☒ **D** $2Al + 6H^+ \rightarrow 2Al^{3+} + 3H_2$

(Total for Question 6 = 1 mark)

7 The metal salt which gives a red colour in a flame test is

☒ **A** barium nitrate.

☒ **B** lithium chloride.

☒ **C** potassium nitrate.

☒ **D** sodium chloride.

(Total for Question 7 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

8 What is the trend in the thermal stability of the carbonates and nitrates as Group 2 is **descended**?

	Carbonates	Nitrates
☒ **A**	decreases	decreases
☒ **B**	decreases	increases
☒ **C**	increases	decreases
☒ **D**	increases	increases

(Total for Question 8 = 1 mark)

9 Which pair of compounds has the more soluble hydroxide and the more soluble sulfate?

☒ **A** $Mg(OH)_2$ and $MgSO_4$

☒ **B** $Mg(OH)_2$ and $SrSO_4$

☒ **C** $Sr(OH)_2$ and $MgSO_4$

☒ **D** $Sr(OH)_2$ and $SrSO_4$

(Total for Question 9 = 1 mark)

10 The table shows the measurement uncertainty of each reading for some laboratory apparatus.

Laboratory apparatus	Measurement uncertainty of each reading / cm^3
burette	±0.05
measuring cylinder, 25 cm^3	±0.5
pipette, 25 cm^3	±0.06
volumetric flask, 25 cm^3	±0.1

The item of laboratory apparatus that would measure a volume of 25 cm^3 with the **lowest** percentage uncertainty is the

☒ **A** burette.

☒ **B** measuring cylinder, 25 cm^3.

☒ **C** pipette, 25 cm^3.

☒ **D** volumetric flask, 25 cm^3.

(Total for Question 10 = 1 mark)

11 On adding chlorine water to aqueous sodium bromide, the resulting solution is

☒ **A** colourless.

☒ **B** pale yellow-green.

☒ **C** red-brown.

☒ **D** purple.

(Total for Question 11 = 1 mark)

12 A solid silver halide was tested as follows:

Test	Result
action of sunlight	solid turned grey
addition of dilute ammonia	solid did not dissolve
addition of concentrated ammonia	solid dissolved

The silver halide is

☒ **A** AgF

☒ **B** AgCl

☒ **C** AgBr

☒ **D** AgI

(Total for Question 12 = 1 mark)

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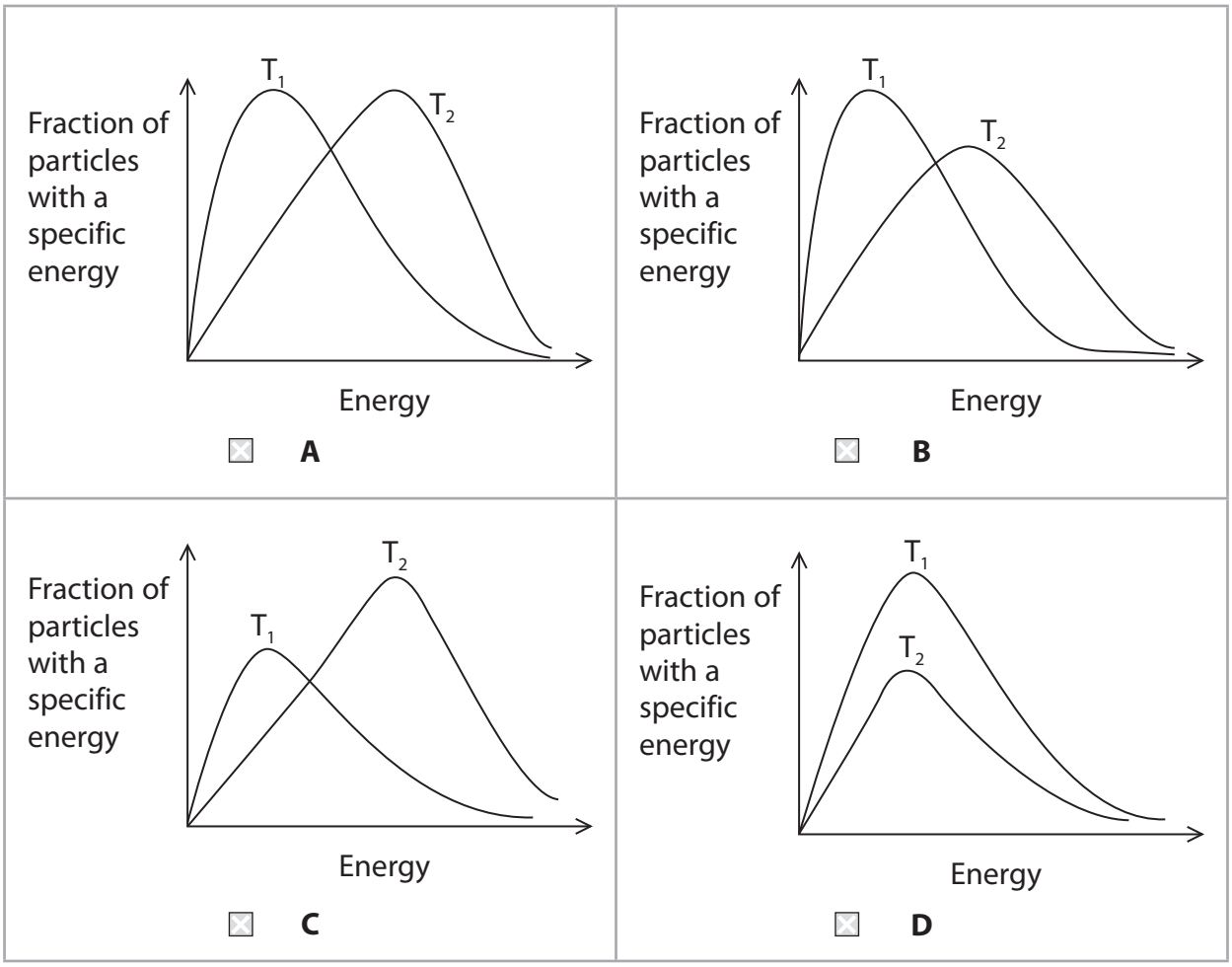
13 This question is about the Maxwell-Boltzmann energy distribution.

The diagram for an **increase** in temperature from T_1 to T_2 is



(Total for Question 13 = 1 mark)

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14 The rate of the reaction between calcium carbonate and acid **increases** when

☒ **A** the particle size of the calcium carbonate decreases.

☒ **B** 1 mol dm^{-3} nitric acid is used instead of 1 mol dm^{-3} hydrochloric acid.

☒ **C** 0.5 mol dm^{-3} sulfuric acid is used instead of 1 mol dm^{-3} hydrochloric acid.

☒ **D** the pressure is increased.

(Total for Question 14 = 1 mark)

15 The most significant factor determining the trend in the rate of hydrolysis of halogenobutanes is

☒ **A** the electronegativity of the halogen.

☒ **B** the magnitude of the halogen ionisation energy.

☒ **C** the oxidising ability of the halogen.

☒ **D** the carbon-halogen bond strength.

(Total for Question 15 = 1 mark)

16 The action of ultraviolet radiation on an oxygen molecule high in the atmosphere results in

☒ **A** no change because O_2 has no dipole.

☒ **B** only increased bond vibration.

☒ **C** the production of two oxygen atoms.

☒ **D** the formation of an oxide ion.

(Total for Question 16 = 1 mark)

17 The mass spectrum of propanal can be clearly distinguished from the mass spectrum of propanone. Only the propanal spectrum has a large peak due to the

☒ **A** $C_3H_6O^+$, molecular ion, $m/e = 58$

☒ **B** $C_3H_5O^+$ fragment, $m/e = 57$

☒ **C** $C_2H_5^+$ fragment, $m/e = 29$

☒ **D** CH_3^+ fragment, $m/e = 15$

(Total for Question 17 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

18 A sample of butan-2-ol was oxidised by heating under reflux with an oxidising agent and then the product was separated for infrared analysis. Apart from the peaks due to the C—C and C—H bonds, which peaks would be present in the IR spectrum of the oxidation product?

- ☒ **A** A peak due to C═O only.
- ☒ **B** A peak due to O—H only.
- ☒ **C** Peaks due to C═O and O—H.
- ☒ **D** Peaks due to C—O, C═O and O—H.

(Total for Question 18 = 1 mark)

19 Which greenhouse gas is produced **only** as a result of anthropogenic activity?

- ☒ **A** carbon dioxide
- ☒ **B** dichlorodifluoromethane
- ☒ **C** methane
- ☒ **D** water vapour

(Total for Question 19 = 1 mark)

20 The first ionisation energy of strontium is less endothermic than that of calcium.

The best explanation for this is that strontium has

- ☒ **A** more protons.
- ☒ **B** more protons and neutrons.
- ☒ **C** 18 and not 8 electrons in its outer shell.
- ☒ **D** more inner electron shells.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

21 Tablets of potassium iodate(V), KIO_3, may be used to protect against the build-up of radioactive iodine in the body. The use of potassium iodate(V) is preferred to potassium iodide because, in hot and humid conditions, the potassium iodate(V) can be stored for much longer.

A very old sample of potassium iodate(V) tablets, which originally contained 85 mg of KIO_3 per tablet, was analysed using the following procedure.

A tablet was crushed, dissolved in deionised water and the solution and washings added to a conical flask. Then potassium iodide, KI, and hydrochloric acid, both in excess, were added to the conical flask. This mixture was titrated with 0.0600 mol dm^{-3} sodium thiosulfate solution.

This procedure was repeated and the following burette readings were obtained.

Titration	1	2	3
Final volume / cm^3	19.90	39.70	39.85
Initial volume / cm^3	0.00	19.90	20.00
Volume added / cm^3	19.90	19.80	19.85
Mean titre / cm^3	19.85		

(a) State why it was **not** essential to carry out the third titration.

(1)

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.....

(b) Starch was added to the titration mixture in order to make the end-point easier to observe.

(i) State the colour change observed at the end-point with starch.

(1)

From ..... to .....

(ii) Identify the substance in the titration mixture that reacts with starch.

(1)

.....

(c) The equations for the reactions involved are

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(i) Calculate the number of moles of sodium thiosulfate that reacted.

(1)

(ii) Calculate the number of moles of iodine that reacted with the thiosulfate.

(1)

(iii) Calculate the mass in **milligrams** of potassium iodate(V) in each tablet.
Give your answer to **three** significant figures.

(3)

(iv) In a radiation emergency, the recommended adult dose is 170 mg of KIO_3 every 24 hours.

Using your result to (c)(iii), suggest whether or not the old tablets of potassium iodate(V) are suitable for use. Justify your answer.

(2)

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(v) The experiment was repeated with a different batch of tablets. The conical flask contained 2.15×10^{-4} mol of potassium iodate(V).

Calculate the minimum volume of 0.100 mol dm^{-3} hydrochloric acid that should be added to ensure that all of the potassium iodate(V) is converted to iodine and hence suggest an appropriate volume to use.

(3)

(d) Potassium iodate(V) can be produced from iodine and potassium hydroxide.

(i) Give the oxidation numbers of iodine in the iodine-containing species in the following equation. Hence classify the reaction.

(2)

$$6KOH + 3I_2 \rightarrow 5KI + KIO_3 + 3H_2O$$

Oxidation Number ....

Type of reaction .....

(ii) State the conditions necessary for this reaction to occur.

(1)

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.....

(Total for Question 21 = 16 marks)

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22 This is a question about alcohols.

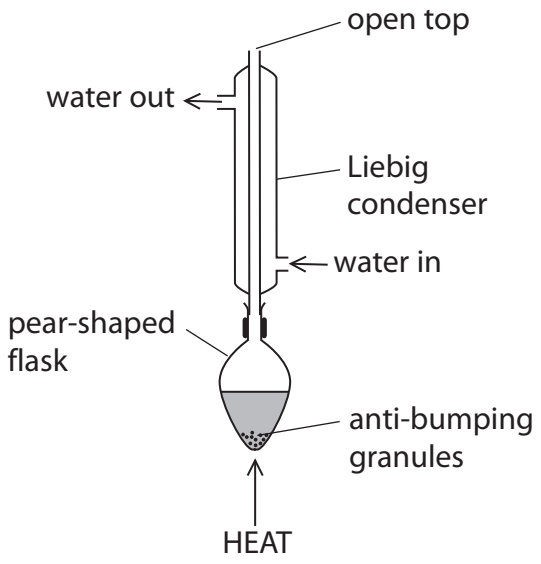
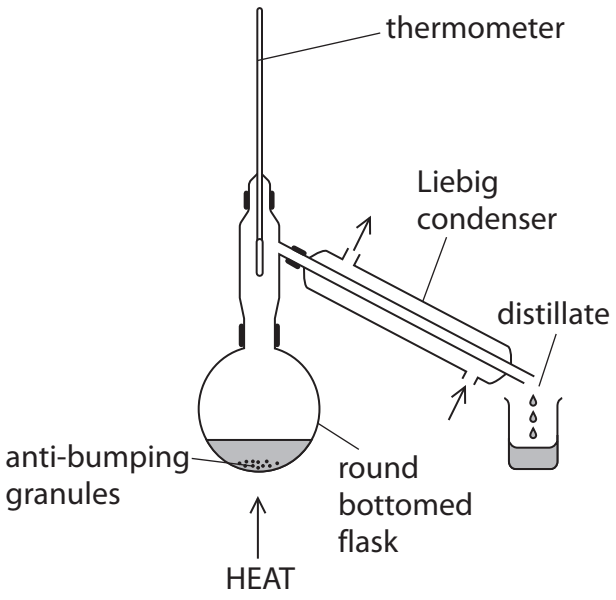
(a) There are two alcohol structural isomers with the molecular formula, C_3H_8O.

Give the **skeletal** formula of these isomers, their systematic names and the classification of the type of alcohol in each case.

(3)

Skeletal formula	Name	Classification

(b) Ethanol can be oxidised by acidified sodium dichromate(VI) to ethanal and then to ethanoic acid. The apparatus may be set up in two ways.

Reflux apparatus	Distillation apparatus
	

(i) Complete the ionic half-equation for the reduction of the dichromate(VI) ions to chromium(III) ions. State symbols are not required.

(2)

$Cr_2O_7^{2-}$ + ... H^+ + ... → ..... + ...

(ii) Describe how the reflux apparatus ensures that any ethanal initially produced is further oxidised to ethanoic acid.

(1)

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(iii) The distillation apparatus effectively separates ethanal from ethanol because of the large difference in boiling temperatures, which is a result of the hydrogen bonding between the molecules in ethanol.

Compound	Boiling temperature / °C
Ethanol, CH_3CH_2OH	79
Ethanal, CH_3CHO	21

Draw a hydrogen bond between two ethanol molecules. Clearly indicate any relevant dipoles and lone pairs of electrons. Label the bond angle about the hydrogen involved in the hydrogen bond and give its value.

(3)

(iv) Explain why hydrogen bonds do **not** form between ethanal molecules.

(1)

(c) Alcohols can be converted into halogenoalkanes.

(i) Write the equation for the reaction between methanol, CH_3OH, and phosphorus(V) chloride, PCl_5.

(1)

(ii) State the experimental observation from this reaction.

(1)

*(iii) Chloroethane can be made from a mixture of ethanol, potassium chloride and concentrated sulfuric acid. Explain why chloroethane can be made in this way, but iodoethane cannot be made from a similar mixture using potassium iodide instead of potassium chloride.

You may use equations to support your explanation.

(3)

(d) Alcohols can be produced from the reaction of halogenoalkanes with aqueous alkali.

(i) Draw the mechanism for this reaction with 1-bromopropane. Show the lone pair involved in the mechanism and any relevant dipoles and curly arrows.

(3)

(ii) The reaction of 1-bromopropane with concentrated alcoholic alkali forms a different organic product. Name the type of reaction and give the **displayed** formula of the product.

(2)

Name of reaction .....

Displayed formula of product

(e) How would you test for the OH group in 2-methylpropan-2-ol without using phosphorus(V) chloride?

Name the reagent and state the observation for a positive test.

(2)

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(Total for Question 22 = 22 marks)

TOTAL FOR SECTION B = 38 MARKS

SECTION C

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

23 Boron nitride, BN, is a compound first made commercially in the 1940s from boric acid and ammonia, in an atmosphere of nitrogen.

It forms structures analogous to graphite and diamond because it is isoelectronic with these corresponding carbon structures. Boron nitride has also been used to form nanotube structures in a similar way to carbon.

Just as synthetic diamonds are produced from graphite by using high temperatures and high pressures, the diamond-like cubic boron nitride can also be made from heating the graphite-like hexagonal boron nitride under high pressure.

Boron nitride forms ceramic materials with very high thermal and chemical stability and, a wide range of uses. For example, they are stable in air up to 1000 °C, which is an advantage over similar graphite materials. The hexagonal form of boron nitride is a very effective lubricant and is also used in cosmetics. However, it is an electrical insulator, in contrast to graphite, which is a good electrical conductor.

(a) (i) Write the equation for the formation of boron nitride from boric acid, H_3BO_3, and ammonia.

State symbols are not required.

(1)

(ii) Suggest why this reaction is carried out in an atmosphere of nitrogen.

(1)

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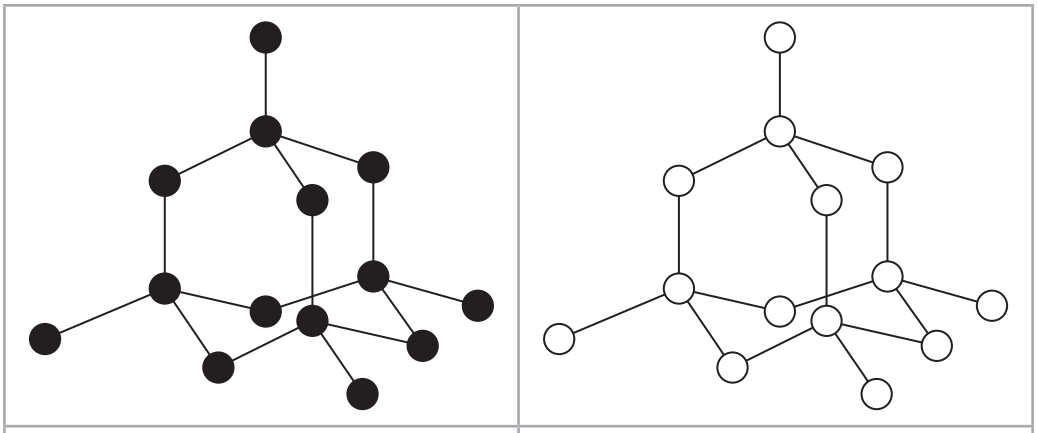
.....

(b) The structure of the cubic boron nitride corresponds to the diamond structure. The boron and nitrogen atoms alternate throughout the structure.

(i) In the left hand box, the diagram shows a section of the diamond structure, where each black circle represents a carbon atom.

In the right hand box label all the nitrogen and boron atoms in the diagram of cubic boron nitride.

(1)



Diamond	Cubic boron nitride

(ii) State the bond angle and shape around the carbon atoms in diamond and fully justify your answer.

(4)

Bond angle ..... Shape .....

Justification .....

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(c) The equilibrium between graphite and diamond is

$$C(\text{graphite}) \rightleftharpoons C(\text{diamond}) \qquad \Delta H = +1.9\,\text{kJ mol}^{-1}$$

The density of graphite is 2.27 g cm^{-3} and the density of diamond is 3.51 g cm^{-3}.

*(i) Suggest why a very high temperature and high pressure are needed to convert graphite to diamond.

(4)

(ii) The use of a catalyst in the conversion of graphite to diamond has been reported. Describe how the addition of a catalyst can lower the temperature required for a reaction.

(3)

(d) Diamond and graphite are stable in air up to approximately 800 °C. Identify **one** of the products if diamond or graphite is heated in air above this temperature.

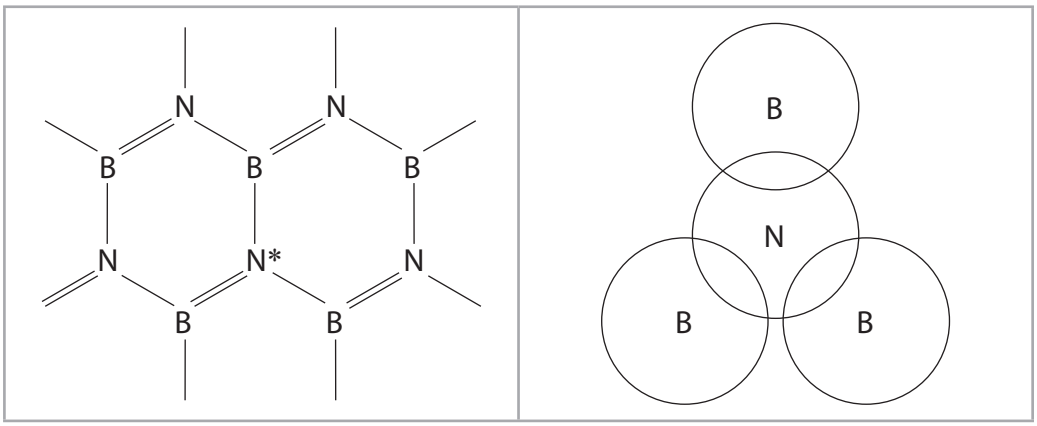
(1)

.....

(e) The structure of hexagonal boron nitride corresponds to that of graphite.

(i) The simplified diagram in the left hand box shows the bonding in hexagonal boron nitride.
In the right hand box, complete the dot and cross diagram showing only the electrons around the nitrogen atom which is labelled with an asterisk (*).
Use (×) for the nitrogen electrons and (•) for the boron electrons.

(1)



*(ii) Describe how each carbon atom is bonded in the graphite structure and hence explain why graphite is a good conductor of electricity. Suggest why hexagonal boron nitride is an electrical insulator.

(3)

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(iii) Graphite and the hexagonal boron nitride are both used as lubricants because of the weak intermolecular forces between the layers of hexagonal rings. Identify these intermolecular forces and describe how they arise.

(3)

(Total for Question 23 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS

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

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
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

* Lanthanide series

* Actinide series