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Surname

Other names

Pearson Edexcel
International
Advanced Level

Centre Number

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Candidate Number

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Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Wednesday 7 January 2015 – Morning

Time: 1 hour 30 minutes

Paper Reference

WCH01/01

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 ►

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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 A solution contains 33 ppm of solute. The mass of solute dissolved in 1 kg of this solution is

- ☐ A 33 g
☐ B 0.33 g
☐ C 0.033 g
☐ D 0.000033 g

(Total for Question 1 = 1 mark)

- 2 The Avogadro constant is equal to the number of

- ☐ A grams of an element which contains 6.02×10^{23} atoms of that element.
☐ B atoms contained in one mole of any element.
☐ C atoms contained in one mole of any monatomic element.
☐ D particles (atoms, ions or molecules) required to make one gram of a substance.

(Total for Question 2 = 1 mark)

- 3 A hydrocarbon contains, by mass, 82.7% carbon and 17.3% hydrogen.

The **molecular** formula of the hydrocarbon is

- ☐ A CH_3
☐ B C_2H_6
☐ C C_2H_5
☐ D C_4H_{10}

(Total for Question 3 = 1 mark)



4 An ion, X^- , contains 36 electrons.

In which block of the Periodic Table would element **X** be found?

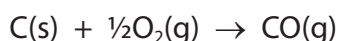
- ☐ A s
- ☐ B p
- ☐ C d
- ☐ D f

(Total for Question 4 = 1 mark)

5 Consider the following data:



Calculate the value of the enthalpy change, in kJ mol^{-1} , for the following reaction.



- ☐ A -243
- ☐ B -111
- ☐ C +111
- ☐ D +243

(Total for Question 5 = 1 mark)

6 Which of the following enthalpy changes cannot be measured **directly** by experiment?

The enthalpy change of

- ☐ A formation of methane.
- ☐ B combustion of hydrogen.
- ☐ C formation of carbon dioxide.
- ☐ D combustion of carbon monoxide.

(Total for Question 6 = 1 mark)



7 Which of the following equations represents a step that is **not** involved in the Born-Haber cycle for lithium iodide, LiI?

- ☐ A $\text{Li(s)} + \frac{1}{2}\text{I}_2\text{(s)} \rightarrow \text{LiI(s)}$
- ☐ B $\frac{1}{2}\text{I}_2\text{(s)} \rightarrow \text{I(g)}$
- ☐ C $\text{Li(s)} \rightarrow \text{Li(g)}$
- ☐ D $\text{I(g)} \rightarrow \text{I}^+\text{(g)} + \text{e}^-$

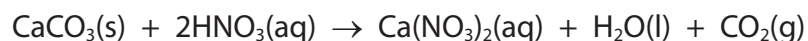
(Total for Question 7 = 1 mark)

8 Which of the following results in the most polarizing cation?

	Cation radius	Cation charge
☐ A	small	small
☐ B	small	large
☐ C	large	small
☐ D	large	large

(Total for Question 8 = 1 mark)

9 Calcium carbonate reacts with dilute nitric acid as follows:



0.05 mol of calcium carbonate was added to a solution containing 0.08 mol of nitric acid.

Which of the following statements is true?

- ☐ A 0.05 mol of carbon dioxide is produced.
- ☐ B 0.08 mol of calcium nitrate is produced.
- ☐ C Calcium carbonate is in excess by 0.01 mol.
- ☐ D Nitric acid is in excess by 0.03 mol.

(Total for Question 9 = 1 mark)



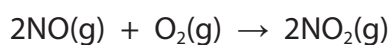
10 In which of the following pairs does each gas occupy the same volume?

All volumes are measured at the same temperature and pressure.

- ☐ **A** 2 g of hydrogen and 14 g of nitrogen.
- ☐ **B** 32 g of methane and 88 g of carbon dioxide.
- ☐ **C** 7 g of carbon monoxide and 16 g of oxygen.
- ☐ **D** 10 g of hydrogen chloride and 10 g of sulfur dioxide.

(Total for Question 10 = 1 mark)

11 Consider the reaction below.



What is the maximum volume, in dm^3 , of nitrogen dioxide that could be obtained in the reaction occurring when 1 dm^3 of nitrogen monoxide is mixed with 2 dm^3 of oxygen, under suitable conditions?

All measurements are made at the same temperature and pressure.

- ☐ **A** 1
- ☐ **B** 2
- ☐ **C** 3
- ☐ **D** 4

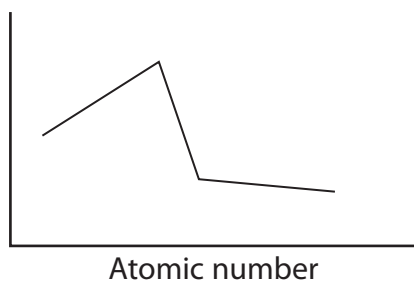
(Total for Question 11 = 1 mark)

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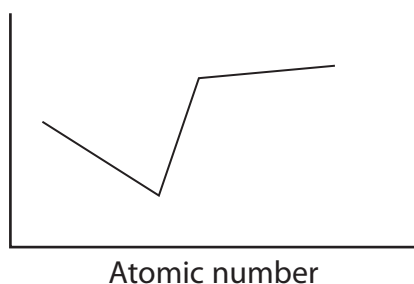


12 Which of the following graphs, not drawn to scale, best represents the trend in the melting temperatures of the elements across Period 3, from sodium to argon?

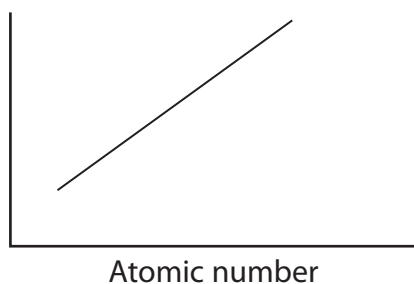
☐ A Melting temperature



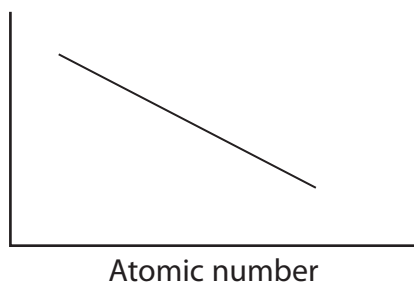
☐ B Melting temperature



☐ C Melting temperature



☐ D Melting temperature



(Total for Question 12 = 1 mark)



13 In an experiment, 3.425 g of lead oxide was reduced to form 3.105 g of lead.

The empirical formula of the lead oxide is

- ☐ **A** PbO
- ☐ **B** Pb₃O₂
- ☐ **C** Pb₃O₄
- ☐ **D** Pb₄O₃

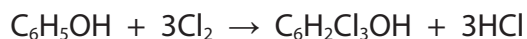
(Total for Question 13 = 1 mark)

14 Which one of the following ions has the smallest radius?

- ☐ **A** F⁻
- ☐ **B** Mg²⁺
- ☐ **C** Na⁺
- ☐ **D** O²⁻

(Total for Question 14 = 1 mark)

15 Phenol, C₆H₅OH, is converted into trichlorophenol (known as TCP), C₆H₂Cl₃OH, according to the equation below.



If 50.0 g of phenol produces 97.6 g of TCP, what is the percentage yield of the TCP?

[Molar masses: phenol = 94 g mol⁻¹; TCP = 197.5 g mol⁻¹]

- ☐ **A** 47.6%
- ☐ **B** 49.4%
- ☐ **C** 51.2%
- ☐ **D** 92.9%

(Total for Question 15 = 1 mark)

16 Which of the following contains a dative covalent bond?

- ☐ **A** N₂
- ☐ **B** NH₃
- ☐ **C** NH₂⁻
- ☐ **D** NH₄⁺

(Total for Question 16 = 1 mark)



17 If the price of one tonne (1000 kg) of sulfur, S, is £160, what is the cost (to the nearest pound) of the sulfur needed to make one tonne of sulfuric acid, H₂SO₄?

- ☐ **A** £52
- ☐ **B** £98
- ☐ **C** £160
- ☐ **D** £490

(Total for Question 17 = 1 mark)

18 Potassium combines with iodine to form potassium iodide.

Which of the following describes the bonding in the three substances?

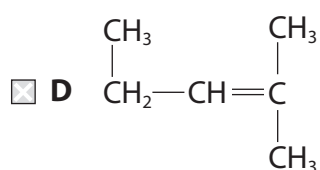
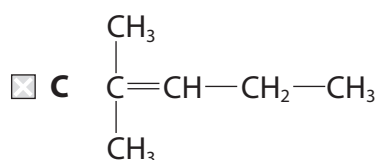
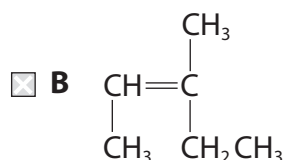
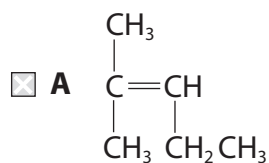
	Potassium	Iodine	Potassium iodide
☐ A	ionic	covalent	ionic
☐ B	metallic	ionic	covalent
☐ C	covalent	covalent	ionic
☐ D	metallic	covalent	ionic

(Total for Question 18 = 1 mark)

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



19 Which of the following does **not** represent the structure of the compound 2-methylpent-2-ene?



(Total for Question 19 = 1 mark)

20 Ions with the same electronic configuration are said to be **isoelectronic**.

Which of the following compounds is made up of isoelectronic ions?

- ☐ A CaO
- ☐ B CaBr₂
- ☐ C Na₂O
- ☐ D LiF

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

21 Crude oil is a source of alkanes.

(a) Name the process by which the hydrocarbons in crude oil are separated.

(1)

(b) The alkane **X** is composed of straight-chain molecules, each with nine carbon atoms.

(i) Give the molecular formula of **X**.

(1)

(ii) **Y** is a branched-chain isomer of **X**.

Y has eight carbon atoms in a straight-chain with **one** methyl group as a side-chain.

Draw the **skeletal formula** of **one** possible structure for **Y**.

Give the name of the structure that you have drawn.

(2)

Skeletal formula:

Name:



(c) A reaction called cracking occurs when the alkane pentadecane, $C_{15}H_{32}$, is heated in the presence of a catalyst.

- (i) Give an equation to show the cracking of one molecule of $C_{15}H_{32}$ to form one molecule of ethene and a molecule of **one** other product.
State symbols are not required.

(1)

- (ii) In practice, cracking pentadecane forms a large number of products.

Suggest why this is so.

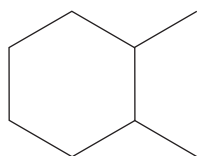
(1)

- (d) In the petroleum industry, some straight-chain alkanes are processed to form cyclic hydrocarbons.

When octane is processed, each molecule of octane produces one molecule of a cyclic hydrocarbon, C_8H_{16} , and three molecules of hydrogen as the only products.

- (i) Complete the **skeletal** formula of one of the possible cyclic hydrocarbons.

(1)



- (ii) Suggest why the petroleum industry processes straight-chain alkanes to form cyclic hydrocarbons.

(1)

(Total for Question 21 = 8 marks)



22 For some reactions, the enthalpy change can be determined by experiment.

(a) Define the term **enthalpy change of reaction**.

(2)

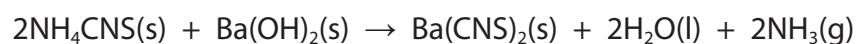
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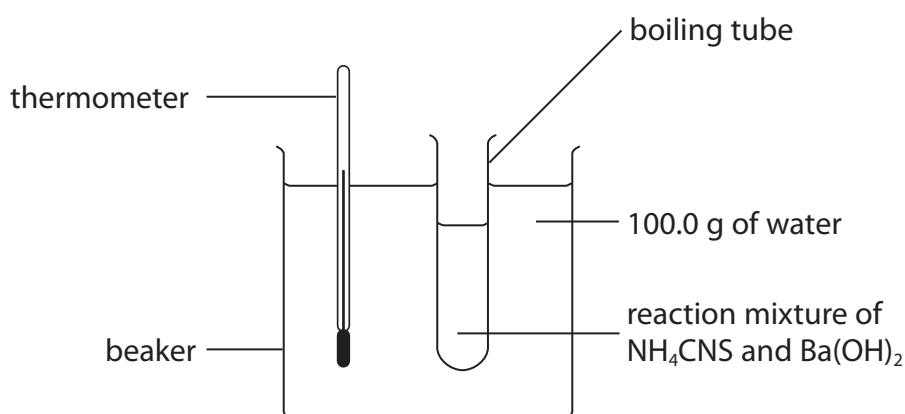
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(b) An equation for the reaction between the two solids ammonium thiocyanate, NH_4CNS , and barium hydroxide, $\text{Ba}(\text{OH})_2$, is shown below.



The following apparatus was set up in order to determine the enthalpy change for the reaction.



In the experiment, 15.22 g of NH_4CNS was reacted with an excess of $\text{Ba}(\text{OH})_2$. The reaction absorbed heat energy from the surroundings. The temperature of the 100.0 g of water fell from 22.0°C to 16.5°C .



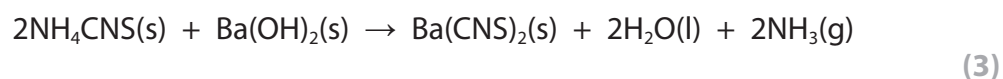
- (i) Calculate the heat energy absorbed, in joules, during the reaction.

Use the equation

$$\text{Heat energy absorbed (J)} = \text{mass of water} \times 4.2 \times \text{temperature change} \quad (1)$$

- (ii) Calculate the number of moles of NH_4CNS used in the experiment. (1)

- (iii) Calculate the enthalpy change of the reaction, in kJ mol^{-1} , to **two** significant figures. Include a sign in your answer.



(c) Standard enthalpy changes of reaction can also be calculated using mean bond enthalpies.

(i) What is meant by the term **mean bond enthalpy**?

(2)

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(ii) Describe the bonding in a $\text{C}=\text{C}$ double bond in terms of the different ways in which the orbitals overlap.

You may draw a diagram if you wish.

(2)

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Space for diagram:



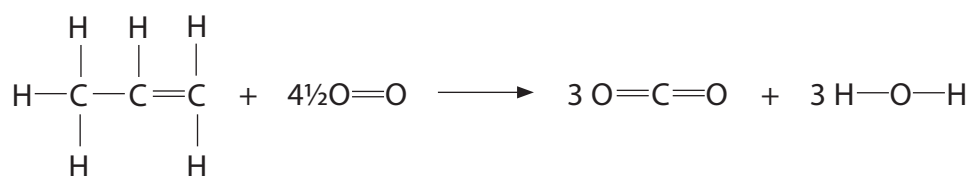
(iii) Suggest why the mean bond enthalpy of a C=C bond is less than twice the mean bond enthalpy of a C—C bond.

(1)

(iv) Use the mean bond enthalpy data in the table, and the equation given below, to calculate a value for the standard enthalpy change of combustion of propene.

(3)

Bond	Mean bond enthalpy / kJ mol ⁻¹
C=C	612
C—C	347
C—H	413
O=O	498
C=O	805
O—H	464



Answer = ... kJ mol⁻¹



*(v) The Data Booklet value for the standard enthalpy change of combustion of propene is $-2058 \text{ kJ mol}^{-1}$.

Explain why the value calculated in (c)(iv) is less exothermic than the Data Booklet value.

(2)

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(Total for Question 22 = 17 marks)



23 Iodine monochloride, ICl, is an interhalogen compound. Molecules of iodine monochloride have a permanent dipole. Alkenes react with ICl, under suitable conditions, in a similar way to the reaction of alkenes with hydrogen chloride, HCl.

(a) Propene reacts with ICl to form two possible organic products.

One of these products is 2-chloro-1-iodopropane.

(i) Complete the mechanism below, by adding curly arrows and the intermediate species.

(3)



(ii) Classify the type and mechanism for the reaction in (a)(i).

(2)

(iii) Draw the structure of the other possible organic product of the reaction of propene with ICl.

(1)



(i) Suggest the essential condition needed for this reaction.

*(ii) The mechanism for the reaction between methane and ICl involves three stages. One of these is the third and final stage, called termination.

In your answer, include:

- the type of reaction and mechanism
- the type of bond fission occurring
- the name and equation for the **first** stage of the mechanism
- the name and equations for the **second** stage of the mechanism
- one equation for a termination step

Curly (half-) arrows and state symbols are **not** required in your equations.

Type of reaction and mechanism

Type of bond fission occurring



(Total for Question 23 = 14 marks)



P 4 5 0 4 1 A 0 1 9 2 4

24 A model of the atom describes a nucleus containing protons and neutrons surrounded by electrons in energy levels.

(a) Complete the table below.

(3)

Sub-atomic particle	Relative mass	Relative charge
proton		
neutron		
electron		

(b) State, in terms of the sub-atomic particles present, the meaning of the term **isotopes**.

(2)

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(c) The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb .

(i) Explain how gaseous atoms of rubidium are ionized in a mass spectrometer.

(2)

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(ii) In a sample of rubidium, the isotope ^{85}Rb has an abundance 2.5 times greater than that of ^{87}Rb .

Calculate the relative atomic mass of rubidium in this sample. Give your answer to **one** decimal place.

(3)

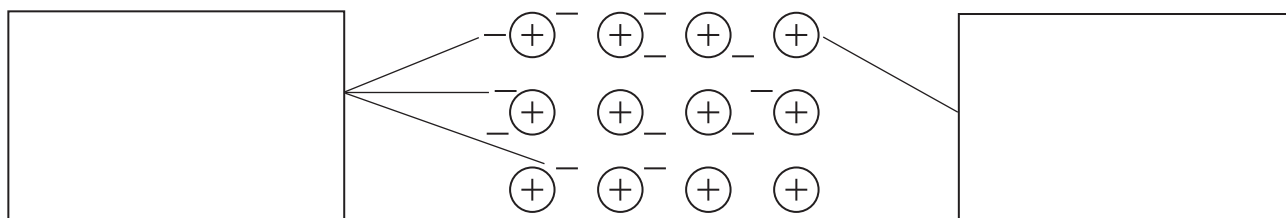
Relative atomic mass = ...



(d) The diagram below illustrates a model of the metallic bonding in rubidium.

Write appropriate labels in the two empty boxes in order to complete the diagram.

(2)



(Total for Question 24 = 12 marks)



25 Ionization energies provide evidence for the arrangement of electrons in atoms.

- (a) (i) Write an equation, including state symbols, to show the **second** ionization energy of magnesium.

(2)

- *(ii) Give **two** reasons why the second ionization energy of magnesium is greater than the first ionization energy of magnesium.

(2)

1

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2

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- (iii) Complete the table by suggesting a value for the **third** ionization energy of magnesium.

(1)

Ionization number	First	Second	Third	Fourth	Fifth
Ionization energy / kJ mol^{-1}	738	1450		10 500	13 600



(b) (i) Give the electronic configurations of phosphorus and of sulfur in s, p and d notation.

(2)

Phosphorus (atomic number 15)

Sulfur (atomic number 16)

(ii) By reference to your answer in (b)(i), explain why the first ionization energy of sulfur is lower than that of phosphorus.

(2)

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(Total for Question 25 = 9 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS



P 4 5 0 4 1 A 0 2 4 2 4