Write your name here

| Surname | Other names |
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**Edexcel GCE**

| Centre Number | Candidate Number |
|---|---|
| | |

# Chemistry

## Advanced Subsidiary
## Unit 1: The Core Principles of Chemistry

Thursday 23 May 2013 – Morning
**Time: 1 hour 30 minutes**

Paper Reference
**6CH01/01**

**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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P 4 1 6 4 9 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 of the following quantities, used in the calculation of the lattice energy of lithium oxide, $Li_2O$, has a negative value?

☒ **A** The enthalpy change of atomization of lithium.

☒ **B** The first ionization energy of lithium.

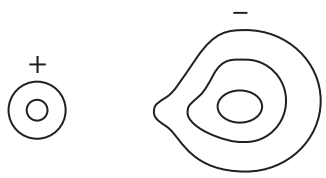
☒ **C** The first electron affinity of oxygen.

☒ **D** The second electron affinity of oxygen.

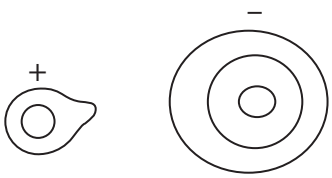
**(Total for Question 1 = 1 mark)**

**2** Which of the diagrams below best represents the shapes of the electron contours in sodium fluoride?

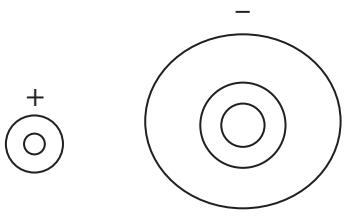
☒ **A**



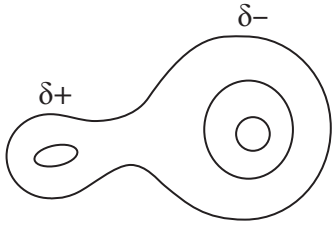

☒ **B**




☒ **C**




☒ **D**




**(Total for Question 2 = 1 mark)**

**3** Which of the equations below represents the first electron affinity for oxygen?

☒ **A** $O_2(g) + 2e^- \rightarrow 2O^-(g)$

☒ **B** $O_2(g) - 2e^- \rightarrow 2O^-(g)$

☒ **C** $\frac{1}{2}O_2(g) + e^- \rightarrow O^-(g)$

☒ **D** $O(g) + e^- \rightarrow O^-(g)$

**(Total for Question 3 = 1 mark)**

**4** Which pair of ions is isoelectronic?

☒ **A** $Ca^{2+}$ and $O^{2-}$

☒ **B** $Na^+$ and $O^{2-}$

☒ **C** $Li^+$ and $Cl^-$

☒ **D** $Mg^{2+}$ and $Cl^-$

**(Total for Question 4 = 1 mark)**

**5** A drop of sodium manganate(VII) solution is placed at the centre of a piece of moist filter paper on a microscope slide. The ends of the paper are clipped to a 30 V DC power supply. After a few minutes,

☒ **A** a purple colour has moved towards the positive terminal.

☒ **B** a purple colour has moved towards the negative terminal.

☒ **C** an orange colour has moved towards the positive terminal.

☒ **D** an orange colour has moved towards the negative terminal.

**(Total for Question 5 = 1 mark)**

**6** How many moles of **ions** are present in 20 $cm^3$ of 0.050 mol $dm^{-3}$ calcium chloride solution, $CaCl_2(aq)$?

☒ **A** 0.0050

☒ **B** 0.0030

☒ **C** 0.0020

☒ **D** 0.0010

**(Total for Question 6 = 1 mark)**

**7** The Avogadro constant is $6.0 \times 10^{23}$ $mol^{-1}$. The number of **atoms** in 1 mol of dinitrogen tetroxide, $N_2O_4$, is

☒ **A** $3.6 \times 10^{24}$

☒ **B** $1.8 \times 10^{24}$

☒ **C** $6.0 \times 10^{23}$

☒ **D** $1.0 \times 10^{23}$

**(Total for Question 7 = 1 mark)**

**8** The equation for the complete combustion of ethane is

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$$

What volume of oxygen, measured at room temperature and pressure, is needed to completely burn 0.1 mol of ethane?

[The volume of 1 mol of any gas measured at room temperature and pressure is 24 $dm^3$]

☒ **A** 2.4 $dm^3$

☒ **B** 4.8 $dm^3$

☒ **C** 8.4 $dm^3$

☒ **D** 16.8 $dm^3$

**(Total for Question 8 = 1 mark)**

**9** A sample of swimming pool water contains 0.482 parts per million (ppm) of chlorine. This is equal to a percentage of

☒ **A** 0.000482

☒ **B** 0.0000482

☒ **C** 0.00000482

☒ **D** 0.000000482

**(Total for Question 9 = 1 mark)**

**10** Bromine has two isotopes with relative isotopic masses 79 and 81. Which of the following values for mass/charge ratio could correspond to a peak in the mass spectrum of bromine, $Br_2$? You should assume the ions detected have a single positive charge.

- ☒ **A** 79.9
- ☒ **B** 80
- ☒ **C** 159
- ☒ **D** 160

**(Total for Question 10 = 1 mark)**

**11** The first five ionization energies of an element, **X**, are shown in the table.

| Ionization energy | 1st | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|---|
| Value / kJ $mol^{-1}$ | 631 | 1235 | 2389 | 7089 | 8844 |

What is the mostly likely formula of the oxide that forms when **X** burns in oxygen?

- ☒ **A** $X_2O$
- ☒ **B** XO
- ☒ **C** $X_2O_3$
- ☒ **D** $XO_2$

**(Total for Question 11 = 1 mark)**

**12** Which of the following has the largest ionic radius?

- ☒ **A** $S^{2-}$
- ☒ **B** $Cl^-$
- ☒ **C** $K^+$
- ☒ **D** $Ca^{2+}$

**(Total for Question 12 = 1 mark)**

**13** Which of the following is a major effect caused by increased carbon dioxide levels arising from the burning of fossil fuels?

☒ **A** Melting of polar ice caps.

☒ **B** Damage to the ozone layer.

☒ **C** Increased acid rain.

☒ **D** Increased skin cancer.

**(Total for Question 13 = 1 mark)**

**14** Which of the following compounds shows geometric (*E-Z* or *cis-trans*) isomerism?

☒ **A** but-1-ene

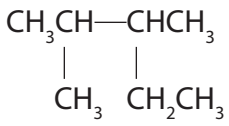
☒ **B** 2-methylbut-1-ene

☒ **C** but-2-ene

☒ **D** 2-methylbut-2-ene

**(Total for Question 14 = 1 mark)**

**15** What is the systematic name for the compound with the following formula?



☒ **A** 2-methyl-3-ethylbutane

☒ **B** 1,2,3-trimethylbutane

☒ **C** 2,3-dimethylpropane

☒ **D** 2,3-dimethylpentane

**(Total for Question 15 = 1 mark)**

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

**16** This question is about the reaction of methane with bromine in sunlight.

**(1)**

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

(a) This reaction is best described as

☒ **A** electrophilic addition.

☒ **B** electrophilic substitution.

☒ **C** free radical addition.

☒ **D** free radical substitution.

(b) One of the steps in the mechanism of this reaction is

**(1)**

$\bullet CH_3 + Br\bullet \rightarrow CH_3Br$

This step is

☒ **A** initiation.

☒ **B** propagation.

☒ **C** termination.

☒ **D** reduction.

(c) This reaction produces a mixture of products.

Which of the following is most likely to form, as well as bromomethane?

**(1)**

☒ **A** ethane

☒ **B** propane

☒ **C** butane

☒ **D** pentane

(d) When human skin is overexposed to sunlight, it is likely to lead to skin cancer.

What is the radiation in sunlight that leads to skin cancer?

**(1)**

☒ **A** microwaves

☒ **B** infrared

☒ **C** visible light

☒ **D** ultraviolet

**(Total for Question 16 = 4 marks)**

**17** Which equation represents the reaction for which the enthalpy change, $\Delta H$, is the mean bond energy of the C-F bond?

☒ **A** $CF_4(g) \rightarrow C(g) + 4F(g)$

☒ **B** $\frac{1}{4}CF_4(g) \rightarrow \frac{1}{4}C(g) + F(g)$

☒ **C** $C(g) + 4F(g) \rightarrow CF_4(g)$

☒ **D** $\frac{1}{4}C(g) + F(g) \rightarrow \frac{1}{4}CF_4(g)$

**(Total for Question 17 = 1 mark)**

**TOTAL FOR SECTION A = 20 MARKS**

## SECTION B

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

**18** The radioactive isotope iodine-131, $^{131}_{53}I$, is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope, $^{127}_{53}I$.

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

**(2)**

| Isotope | $^{131}_{53}I$ | $^{127}_{53}I$ |
|---|---|---|
| Number of protons | | |
| Number of neutrons | | |

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

**(1)**

.....

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

**(1)**

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(d) Nuclear power stations are often proposed as suitable alternatives to those burning coal, gas or oil.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

**(1)**

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**(Total for Question 18 = 5 marks)**

**19** This question is about the elements arsenic to rubidium which have atomic numbers 33 to 37.

The first ionization energies, $E_{m1}$, of these elements are given in the table.

| Element | As | Se | Br | Kr | Rb |
|---|---|---|---|---|---|
| $E_{m1}$ / kJ mol$^{-1}$ | 947 | 941 | 1140 | 1351 | 403 |

(a) Write the equation, with state symbols, which represents the first ionization energy of arsenic.

**(2)**

(b) Suggest the formulae of the hydrides of arsenic and selenium.

**(2)**

(c) (i) Complete the electronic configuration for an arsenic and a selenium atom using the electrons-in-boxes notation.

**(2)**

| | | 4s | 4p | | |
|---|---|---|---|---|---|
| **As** | [Ar] 3d$^{10}$ | ↑↓ | | | |
| **Se** | [Ar] 3d$^{10}$ | ↑↓ | | | |

*(ii) Explain why the first ionization energy of selenium is lower than that of arsenic.

**(2)**

*(d) Explain why the first ionization energy of krypton is higher than that of selenium.

**(2)**

*(e) Explain why the first ionization energy of rubidium is lower than that of krypton.

**(2)**

(f) Which of the elements, arsenic to rubidium, is likely to have atoms with the smallest atomic radius?

**(1)**

**(Total for Question 19 = 13 marks)**

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**20** Copper(II) sulfate solution, $CuSO_4(aq)$, can be made by adding an excess of solid copper(II) oxide, CuO, to boiling dilute sulfuric acid. This is an exothermic reaction.

The balanced equation for this reaction is

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

(a) (i) Complete the ionic equation for this reaction, including state symbols.

**(2)**

$CuO(s) +$

(ii) Calculate the mass of copper(II) oxide needed, if a 10% excess is required, when 0.020 mol of sulfuric acid is completely reacted.

[Relative atomic masses: Cu = 63.5 and O = 16.0]

**(2)**

(b) (i) Suggest, with a reason, how the copper(II) oxide should be added to the boiling sulfuric acid.

**(2)**

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(ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

To prepare crystals of copper(II) sulfate-5-water, $CuSO_4.5H_2O$, the resulting solution is boiled to remove excess water.

How would you know when sufficient water had been removed?

**(1)**

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(iii) After cooling the solution, crystals form. State the colour of the crystals.

**(1)**

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(iv) The crystals all have the same shape. What does this indicate about the arrangement of the ions?

**(1)**

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(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$. Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

**(2)**

(ii) Calculate the percentage yield if 2.7 g of copper(II) sulfate-5-water is obtained from 0.020 mol of sulfuric acid.

**(2)**

(iii) What is the most likely reason for the yield being well below 100%?

**(1)**

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(d) When the crystals are heated, they turn white. On adding water, they return to their original colour. Suggest a use for this reaction.

**(1)**

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**(Total for Question 20 = 15 marks)**

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**21** Sodium hydrogencarbonate decomposes on heating to form sodium carbonate. It is difficult to measure the enthalpy change of this reaction directly.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

One method of determining this enthalpy change is to react known amounts of sodium hydrogencarbonate and sodium carbonate, separately, with excess dilute hydrochloric acid.

(a) 0.010 mol of solid sodium hydrogencarbonate was added to 25 $cm^3$ of dilute hydrochloric acid. A temperature rise of 11 °C was measured using a thermometer graduated at 1 °C intervals.

(i) Calculate the heat energy produced by this reaction using the equation:

Energy transferred in joules = mass × 4.18 × change in temperature

**(1)**

(ii) Calculate the standard enthalpy change for the reaction when one mole of sodium hydrogencarbonate reacts with hydrochloric acid.

Remember to include a sign and units with your answer which should be given to three significant figures.

**(2)**

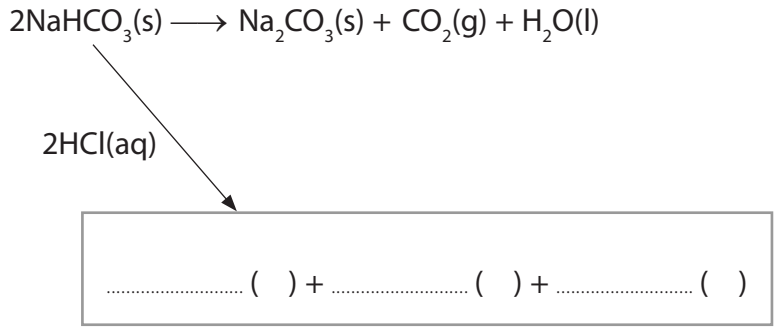
*(b) The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be

$\Delta H^{\ominus} = -321.6$ kJ mol$^{-1}$

Complete the Hess energy cycle below by adding the missing arrow and entities. Use it to calculate the standard enthalpy change for the decomposition of two moles of sodium hydrogencarbonate as in the equation below.

Remember to show your reasoning clearly.

**(5)**



(c) The uncertainty for each thermometer reading is ± 0.5 °C.
Calculate the percentage error in the temperature rise of 11 °C.

**(1)**

(d) Sodium hydrogencarbonate is used in cooking. Suggest what it is used for and how it works.

**(2)**

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**(Total for Question 21 = 11 marks)**

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**22** This question is about ethene and its reactions.

Ethene is produced in industry by cracking.

(a) (i) Write the equation for the cracking of dodecane, $C_{12}H_{26}$, to produce one mole of ethene as the only alkene product.

**(1)**

(ii) Draw a labelled diagram of the apparatus and materials you would use to crack dodecane and collect a sample of the gaseous alkene in the laboratory.

**(4)**

(b) Draw a diagram to show the regions of electron density in both parts of the double bond between the carbon atoms in ethene. Label each region with appropriate symbols.

**(2)**

(c) (i) Give the name and structural formula for the product of the reaction between ethene and bromine, $Br_2(l)$.

**(2)**

Name .....

Formula

(ii) Give the mechanism for the reaction between ethene and bromine.

**(3)**

(d) Give the displayed formula for the organic product of the reaction between ethene and acidified potassium manganate(VII).

**(1)**

(e) (i) Write a balanced equation for the formation of poly(ethene) from ethene, showing the structure of the polymer clearly.

**(2)**

(ii) Comment on the atom economy of the reaction in (e)(i).

**(1)**

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**(Total for Question 22 = 16 marks)**

**TOTAL FOR SECTION B = 60 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