

Please check the examination details below before entering your candidate information

Candidate surname

Other names

**Pearson Edexcel  
Level 3 GCE**

Centre Number

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Candidate Number

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Time 1 hour 45 minutes

Paper  
reference

**9CH0/01**

**Chemistry**

**Advanced**

**PAPER 1: Advanced Inorganic and Physical Chemistry**

**Candidates must have: Scientific calculator  
Data Booklet  
Ruler**

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.*
- Show all your working in calculations and include units where appropriate.

## Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets  
– *use this as a guide as to how much time to spend on each question.*
- For the question marked with an **asterisk** (\*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

## Advice

- Read each question carefully before you start to answer it.
- Check your answers if you have time at the end.
- Good luck with your examination.

Turn over ►

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Pearson

**Answer ALL questions.**

**Some questions must be answered with a cross  $\boxtimes$ .  
If you change your mind about an answer, put a line through the box  $\boxtimes$   
and then mark your new answer with a cross  $\boxtimes$ .**

**1** This is a question about atoms, isotopes and ions.

(a) Which of the following pairs of ions is isoelectronic?

(1)

- A**  $\text{N}^{3-}$  and  $\text{Cl}^-$
- B**  $\text{O}^{2-}$  and  $\text{S}^{2-}$
- C**  $\text{Na}^+$  and  $\text{K}^+$
- D**  $\text{Na}^+$  and  $\text{Mg}^{2+}$

(b) Which is a correct definition of relative isotopic mass?

(1)

- A** the weighted mean mass of an atom of an element relative to one twelfth of the mass of an atom of the isotope carbon-12
- B** the mass of one atom of an isotope relative to one twelfth of the mass of an atom of the isotope carbon-12
- C** the weighted mean mass of an atom of an element relative to 12 g of the isotope carbon-12
- D** the mass of one atom of an isotope relative to the mass of 12 g of the isotope carbon-12

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- (c) The percentage composition of the two bromine isotopes in a sample is given in the table.

Isotope	Relative isotopic mass	Percentage abundance
bromine-79	78.918	50.52
bromine-81	80.916	49.48

Calculate the relative atomic mass of bromine in this sample.  
Give your answer to two decimal places.

(2)

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

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2 Barium ions can be identified by their flame colour.

(a) Which of the following should be used for a flame test on barium carbonate? (1)

- A iron wire and water
- B iron wire and concentrated hydrochloric acid
- C nichrome wire and water
- D nichrome wire and concentrated hydrochloric acid

(b) What colour do barium ions give in a flame test? (1)

- A green
- B lilac
- C red
- D yellow

(c) A flame test was carried out on a mixture of barium chloride and magnesium chloride.

How does the presence of magnesium ions affect the appearance of the flame colour of barium ions? (1)

- A the colour is more intense
- B a bright white colour completely masks the barium colour
- C there is no change
- D the barium colour is decreased by the white magnesium flame colour

**(Total for Question 2 = 3 marks)**



3 This question is about catalytic converters.

(a) Catalytic converters contain metals such as platinum.

Describe the bonding in platinum.  
You may include a diagram in your answer.

(2)

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(b) A catalytic converter decreases the emissions of gases, such as carbon monoxide and nitrogen monoxide, from an internal combustion engine.

Describe the stages in a catalytic converter that result in this decrease.  
No equations are required.

(3)

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**(Total for Question 3 = 5 marks)**



4 Ionisation energies provide information about the number of electrons and the arrangement of the electrons in an atom of an element.

(a) A student's definition of first ionisation energy is shown.

First ionisation energy is the energy released when one mole of gaseous atoms loses one mole of electrons to form one mole of gaseous 1+ ions.

There is one incorrect word in the student's definition.

Identify the word, giving the reason why this word is incorrect.

(2)

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(b) Write an equation for the **second** ionisation energy of oxygen.  
Include state symbols.

(2)





(d) The successive ionisation energies for magnesium are given in the table.

Electron number removed	1	2	3	4	5	6	7	8	9	10	11	12
Ionisation energy / $\text{kJ mol}^{-1}$	738	1451	7733	10541	13629	17995	21704	25657	31644	35463	169996	189371
Log (ionisation energy)	2.87	3.16	3.89	4.02	4.13		4.34	4.41	4.50	4.55	5.23	

(i) Complete the table. (1)

(ii) Give a reason why the logarithm of the ionisation energy, rather than just the ionisation energy, is used to plot a graph. (1)

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(iii) Give a reason why the successive ionisation energies increase. (1)

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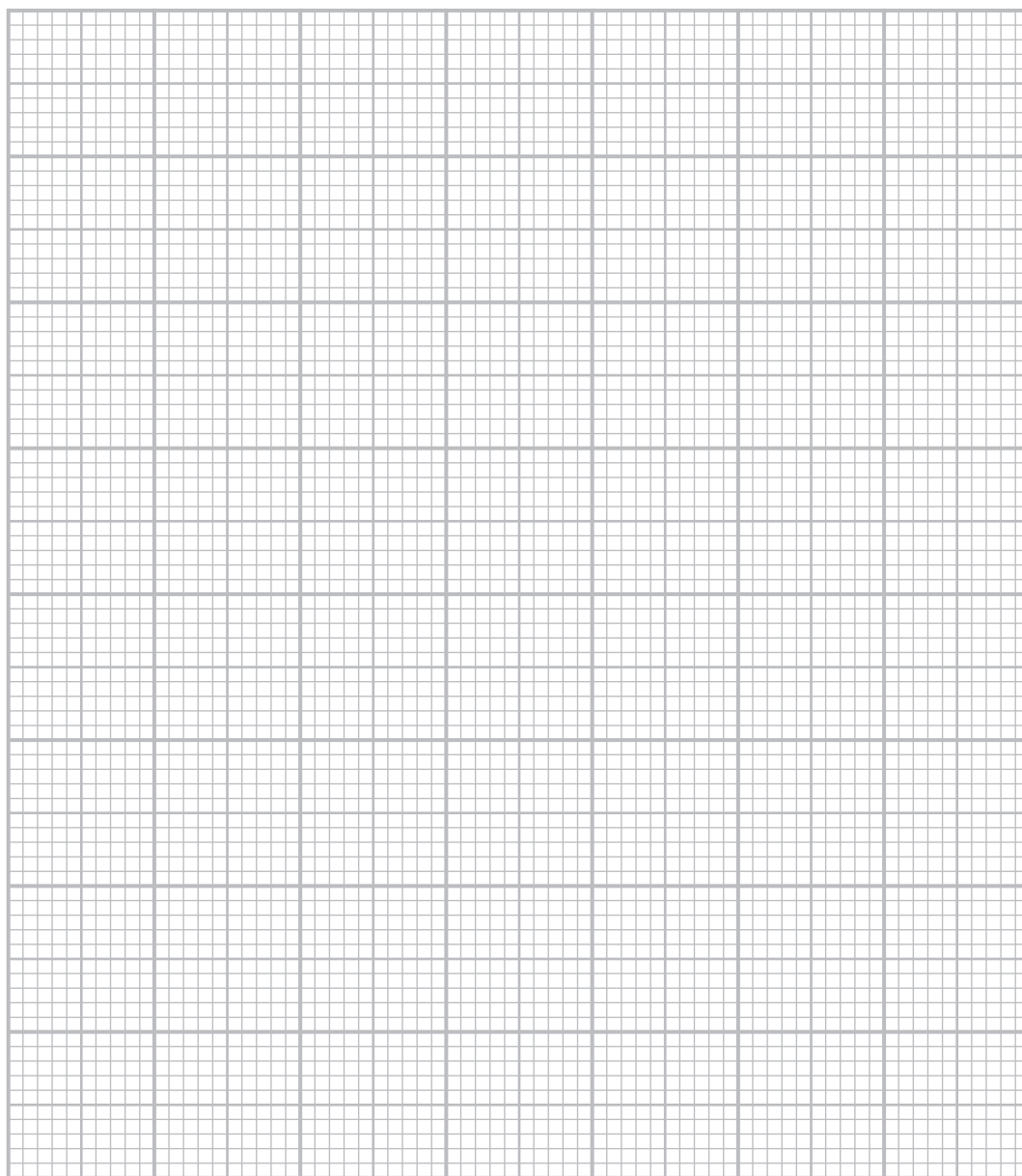




(iv) Plot the graph of  $\log(\text{ionisation energy})$  against electron number removed.

Join the individual points using straight lines.

(3)



(v) Identify on the graph, using a circle, the points that represent the removal of the electrons in the **outermost** energy level of magnesium.

(1)

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(e) Estimate a value for the first ionisation energy of oxygen given the data in the table.

(1)

Element	First ionisation energy / $\text{kJ mol}^{-1}$
carbon	1086
nitrogen	1402
oxygen	.....

(Total for Question 4 = 15 marks)

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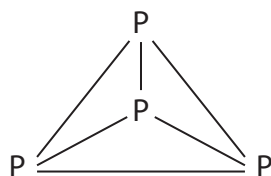
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5 The halogens are elements in Group 7 of the Periodic Table.

(a) Chlorine compounds have many uses, including water treatment.

(i) Chlorine and phosphorus ( $P_4$ ) can react to form phosphorus(V) chloride.

The structure of a molecule of phosphorus is



Some mean bond enthalpy values are shown in the table.

Bond	Mean bond enthalpy / $\text{kJ mol}^{-1}$
P—P	+198
Cl—Cl	+243
P—Cl	+326

Calculate the enthalpy change for the reaction between chlorine and phosphorus to form phosphorus(V) chloride.



(3)



(ii) Give a reason why bond enthalpy values are always positive.

(1)

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(b) Sodium chlorate(I) is a bleaching agent.

(i) Sodium chlorate(I) can be made by the reaction of chlorine with sodium hydroxide.

Show, by using oxidation numbers, that this reaction is disproportionation.



(2)

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(ii) A different bleaching agent can be made by the reaction of chlorine with sodium hydroxide under different conditions.

Balance this equation.



(1)

(iii) What conditions are required for the reaction in (b)(ii)?

(1)

- A** cold and dilute alkali
- B** cold and concentrated alkali
- C** hot alkali
- D** excess chlorine

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- (c) The halogens can be identified by their colour in an organic solvent such as hexane or cyclohexane.

Which sequence of colours is correct for chlorine, bromine and iodine dissolved in an organic solvent?

(1)

	Chlorine	Bromine	Iodine
<input type="checkbox"/> A	orange	red-brown	black
<input type="checkbox"/> B	pale green	orange	black
<input type="checkbox"/> C	orange	red-brown	purple
<input type="checkbox"/> D	pale green	orange	purple

- (d) Halide ions can be identified by their reaction with silver nitrate.

- (i) Write the **ionic** equation for the reaction between aqueous solutions of sodium iodide and silver nitrate. Include state symbols.

(2)

- (ii) A solution containing 0.010 mol of a halide ion was reacted with excess silver nitrate and produced 1.88 g of precipitate.

Identify the halide ion.  
Justify your answer.

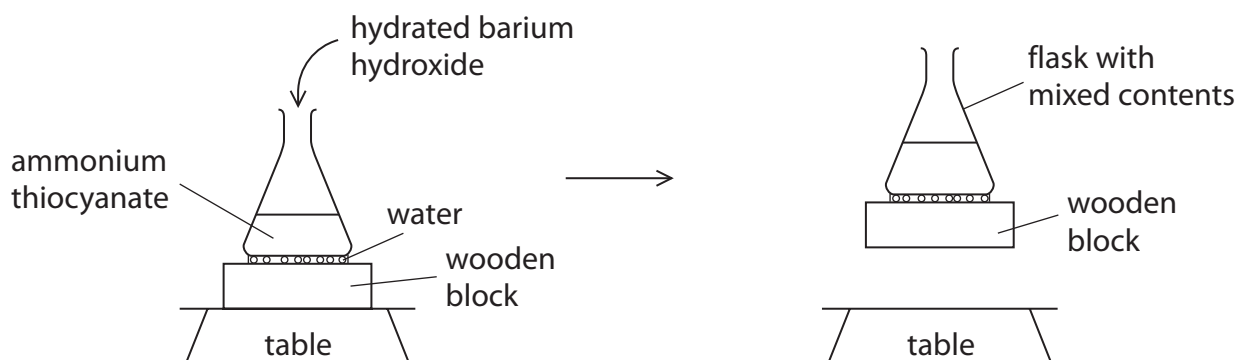
(2)

(Total for Question 5 = 13 marks)



6 This question is about entropy.

- (a) Some hydrated barium hydroxide is added to ammonium thiocyanate in a flask which is placed on a few drops of water on a wooden block. After the addition, the contents are stirred and then the flask can be lifted up with the wooden block attached, as shown.



The equation for the reaction is



- (i) Give **two** reasons why you would expect  $\Delta S_{\text{system}}^{\ominus}$  to be positive.

(2)

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- (ii) Explain why the wooden block is lifted up by the flask.

(2)

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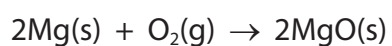
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(b) What is the standard molar entropy change,  $\Delta S_{\text{system}}^{\ominus}$ , in  $\text{JK}^{-1} \text{mol}^{-1}$ , for the reaction shown?



Substance	Standard molar entropy, $S^{\ominus} / \text{JK}^{-1} \text{mol}^{-1}$
Mg(s)	32.7
O <sub>2</sub> (g)	205.0
MgO(s)	26.9

(1)

- A +210.8
- B -210.8
- C +216.6
- D -216.6

(Total for Question 6 = 5 marks)

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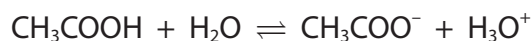
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7 This question is about acids and buffer solutions.

(a) Ethanoic acid,  $\text{CH}_3\text{COOH}$ , is a monobasic acid.



Give a reason why only the proton from the carboxylic acid group, and not from the methyl group, is donated to a water molecule.

(1)

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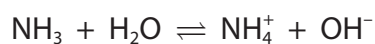
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(b) The reaction of ammonia with water can be represented by



Which is the acid-conjugate base pair?

(1)

	Acid	Conjugate base
<input type="checkbox"/> A	$\text{NH}_3$	$\text{OH}^-$
<input type="checkbox"/> B	$\text{NH}_3$	$\text{NH}_4^+$
<input type="checkbox"/> C	$\text{H}_2\text{O}$	$\text{OH}^-$
<input type="checkbox"/> D	$\text{H}_2\text{O}$	$\text{NH}_4^+$





- (c) A commercial nitric acid solution,  $\text{HNO}_3(\text{aq})$ , has a concentration of  $15.9 \text{ mol dm}^{-3}$ .  
A  $15.0 \text{ cm}^3$  sample was made up to  $100 \text{ cm}^3$  by adding deionised water.

Calculate the pH of this diluted solution.

(2)

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(d) Propanoic acid is a weak acid.

- (i) Calculate the pH of a  $0.100 \text{ mol dm}^{-3}$  solution of propanoic acid at 298 K.  
Give your answer to an appropriate number of significant figures.

$$[K_a = 1.35 \times 10^{-5} \text{ mol dm}^{-3} \text{ at } 298 \text{ K}]$$

(3)

- (ii) State **two** assumptions that you made in the calculation in d(i).

(2)

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(e) A buffer solution was made using  $20.0 \text{ cm}^3$  of a butanoic acid solution, of concentration  $0.100 \text{ mol dm}^{-3}$  and  $30.0 \text{ cm}^3$  of sodium butanoate solution, of concentration  $0.305 \text{ mol dm}^{-3}$ .

$[K_a = 1.52 \times 10^{-5} \text{ mol dm}^{-3} \text{ at } 298\text{K}]$

(i) Calculate the pH of this buffer solution at 298 K. (4)

(ii) Explain why the pH of the buffer solution hardly changes when a few drops of sodium hydroxide solution are added to it. Include an equation or equations in your answer. Use  $\text{C}_3\text{H}_7\text{COOH}$  as the formula for butanoic acid. (2)

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(Total for Question 7 = 15 marks)



**8** Transition metals form complex ions.

(a) Complex ions have a central metal ion surrounded by ligands.

(i) Give a reason why the ammonium ion cannot act as a ligand.

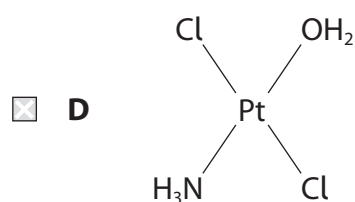
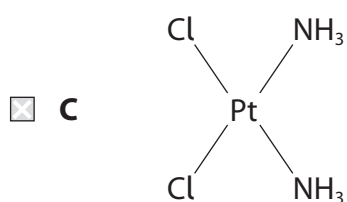
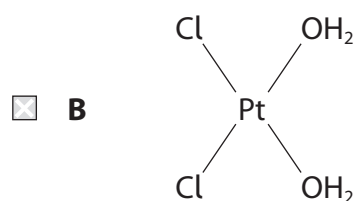
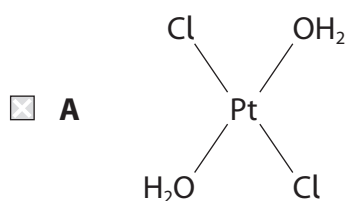
(1)

(ii) Explain why the complex ions  $[\text{Co}(\text{NH}_3)_6]^{2+}$  and  $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$  are coloured and have different colours.

(4)

(b) Which of these complexes is used in the treatment of cancer?

(1)



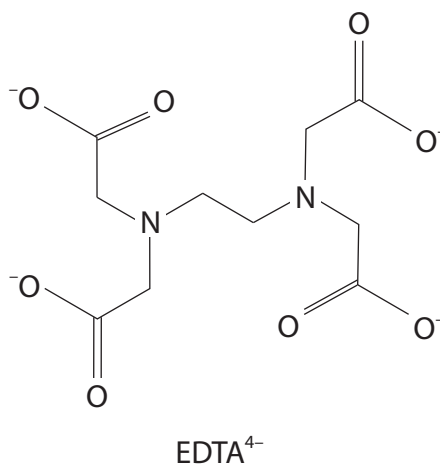
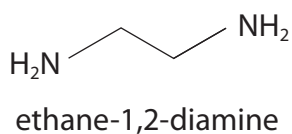
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(c) Compare and contrast the complex ions formed by cobalt(III) ions with the ligand ethane-1,2-diamine and with the ligand  $\text{EDTA}^{4-}$ .

Ignore any difference in colour.



(4)

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- (d) Hydrated chromium(III) chloride,  $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ , dissolves in water to form a number of different complex ions containing both chloride and water ligands.

The general formula of these complex ions is  $[\text{Cr}(\text{H}_2\text{O})_x(\text{Cl})_y]^{(3-y)+}$

In an experiment, 0.10 mol of a complex reacted with excess silver nitrate solution to produce 0.20 mol of silver chloride.

Chloride ions which are ligands within the complex do not react with silver nitrate.

Deduce the formula of this chromium(III) complex ion. Justify your answer.

(2)

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**(Total for Question 8 = 12 marks)**



9 This question is about lattice energies.

(a) The table shows the theoretical and experimental lattice energy values of two compounds.

Compound	Theoretical lattice energy / $\text{kJ mol}^{-1}$	Experimental lattice energy / $\text{kJ mol}^{-1}$
magnesium iodide	-1944	-2327
barium iodide	-1831	-1877

(i) State what can be deduced by the close similarity of the lattice energy values for barium iodide.

(1)

(ii) Explain why there is a significant difference in the lattice energy values for magnesium iodide.

(4)



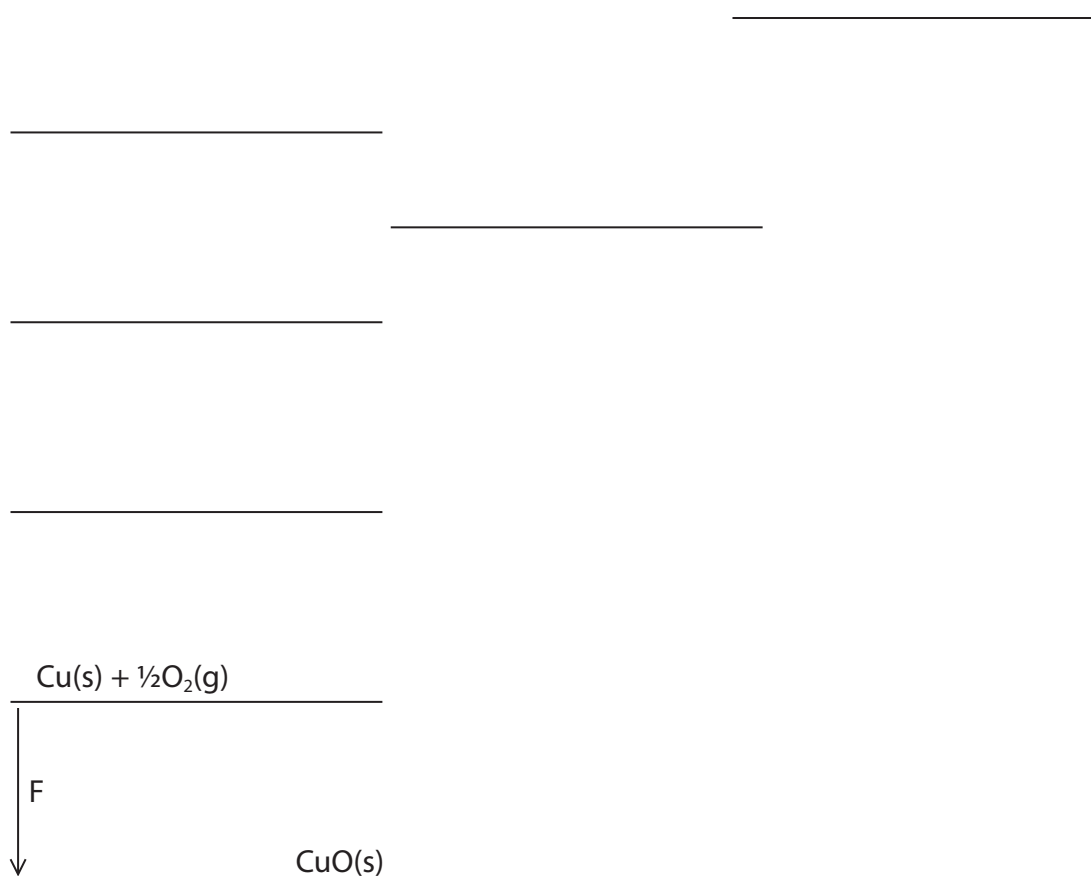
(b) Data for the Born-Haber cycle for copper(II) oxide are given in the table.

Label	Energy change	Value / $\text{kJ mol}^{-1}$
A	standard enthalpy change of atomisation of copper	+338
B	standard enthalpy change of atomisation of oxygen	+249
C	sum of first and second ionisation energies of copper	+2704
D	first electron affinity of oxygen	-141
E	second electron affinity of oxygen	+798
F	standard enthalpy change of formation of copper(II) oxide	-157

(i) Complete the diagram of the Born-Haber cycle for copper(II) oxide.

Include labels of enthalpy changes with arrows indicating the direction of change, and the respective species with state symbols.

(4)

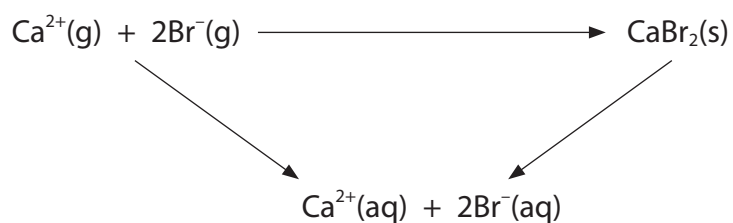




(ii) Calculate the lattice energy of copper(II) oxide.

(1)

(c) A different energy cycle can be used to calculate lattice energy.



Enthalpy change	Value / $\text{kJ mol}^{-1}$
enthalpy change of solution of $\text{CaBr}_2$	-73
enthalpy change of hydration of $\text{Ca}^{2+}$	-1577
enthalpy change of hydration of $\text{Br}^{-}$	-336

Calculate the lattice energy of calcium bromide.

(2)

(Total for Question 9 = 12 marks)



P 6 5 4 6 3 A 0 2 5 2 8



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(Total for Question 10 = 6 marks)

**TOTAL FOR PAPER = 90 MARKS**



P 6 5 4 6 3 A 0 2 7 2 8

# The Periodic Table of Elements

1 2 3 4 5 6 7 0 (8) (18)

1.0  
**H**  
hydrogen  
1

### Key

relative atomic mass  
**atomic symbol**  
name  
atomic (proton) number

(1) (2)

6.9  
**Li**  
lithium  
3

9.0  
**Be**  
beryllium  
4

23.0  
**Na**  
sodium  
11

24.3  
**Mg**  
magnesium  
12

(13)

10.8  
**B**  
boron  
5

12.0  
**C**  
carbon  
6

27.0  
**Al**  
aluminium  
13

(14)

14.0  
**N**  
nitrogen  
7

14.0  
**O**  
oxygen  
8

31.0  
**P**  
phosphorus  
15

32.1  
**S**  
sulfur  
16

(15)

14.0  
**N**  
nitrogen  
7

14.0  
**O**  
oxygen  
8

31.0  
**P**  
phosphorus  
15

32.1  
**S**  
sulfur  
16

(16)

19.0  
**F**  
fluorine  
9

35.5  
**Cl**  
chlorine  
17

(17)

19.0  
**F**  
fluorine  
9

35.5  
**Cl**  
chlorine  
17

(18)

4.0  
**He**  
helium  
2

20.2  
**Ne**  
neon  
10

39.9  
**Ar**  
argon  
18

83.8  
**Kr**  
krypton  
36

131.3  
**Xe**  
xenon  
54

[222]  
**Rn**  
radon  
86

(12)

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

112.4  
**Cd**  
cadmium  
48

114.8  
**In**  
indium  
49

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

(11)

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

112.4  
**Cd**  
cadmium  
48

114.8  
**In**  
indium  
49

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

(10)

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

195.1  
**Pt**  
platinum  
78

197.0  
**Au**  
gold  
79

272  
**Rg**  
roentgenium  
111

(9)

58.9  
**Co**  
cobalt  
27

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

195.1  
**Pt**  
platinum  
78

197.0  
**Au**  
gold  
79

272  
**Rg**  
roentgenium  
111

(8)

55.8  
**Fe**  
iron  
26

101.1  
**Ru**  
ruthenium  
44

190.2  
**Os**  
osmium  
76

277  
**Hs**  
hasnium  
108

(7)

54.9  
**Mn**  
manganese  
25

[98]  
**Tc**  
technetium  
43

186.2  
**Re**  
rhenium  
75

264  
**Bh**  
bohrium  
107

(6)

52.0  
**Cr**  
chromium  
24

95.9  
**Mo**  
molybdenum  
42

183.8  
**W**  
tungsten  
74

266  
**Sg**  
seaborgium  
106

(5)

50.9  
**V**  
vanadium  
23

92.9  
**Nb**  
niobium  
41

180.9  
**Ta**  
tantalum  
73

262  
**Db**  
dubnium  
105

(4)

47.9  
**Ti**  
titanium  
22

91.2  
**Zr**  
zirconium  
40

178.5  
**Hf**  
hafnium  
72

261  
**Rf**  
rutherfordium  
104

(3)

45.0  
**Sc**  
scandium  
21

88.9  
**Y**  
yttrium  
39

138.9  
**La\***  
lanthanum  
57

227  
**Ac\***  
actinium  
89

(2)

9.0  
**Be**  
beryllium  
4

24.3  
**Mg**  
magnesium  
12

40.1  
**Ca**  
calcium  
20

87.6  
**Sr**  
strontium  
38

137.3  
**Ba**  
barium  
56

226  
**Ra**  
radium  
88

(1)

6.9  
**Li**  
lithium  
3

9.0  
**Be**  
beryllium  
4

23.0  
**Na**  
sodium  
11

24.3  
**Mg**  
magnesium  
12

39.1  
**K**  
potassium  
19

85.5  
**Rb**  
rubidium  
37

132.9  
**Cs**  
caesium  
55

223  
**Fr**  
francium  
87

Elements with atomic numbers 112-116 have been reported but not fully authenticated

\* Lanthanide series

\* Actinide series

140	141	144	150	152	157	163	165	167	169	173	175
<b>Ce</b> cerium 58	<b>Pr</b> praseodymium 59	<b>Nd</b> neodymium 60	<b>Pm</b> promethium 61	<b>Eu</b> europium 63	<b>Gd</b> gadolinium 64	<b>Dy</b> dysprosium 66	<b>Ho</b> holmium 67	<b>Er</b> erbium 68	<b>Tm</b> thulium 69	<b>Yb</b> ytterbium 70	<b>Lu</b> lutetium 71
232	[231]	238	[237]	[242]	[247]	[251]	[254]	[253]	[256]	[254]	[257]
<b>Th</b> thorium 90	<b>Pa</b> protactinium 91	<b>U</b> uranium 92	<b>Np</b> neptunium 93	<b>Pu</b> plutonium 94	<b>Am</b> americium 95	<b>Cf</b> californium 98	<b>Es</b> einsteinium 99	<b>Fm</b> fermium 100	<b>Md</b> mendelevium 101	<b>No</b> nobelium 102	<b>Lr</b> lawrencium 103

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