13 Which molecule has the largest bond angle?

- ☒ **A** BF_3
- ☒ **B** CF_4
- ☒ **C** H_2O
- ☒ **D** NH_3

(Total for Question 13 = 1 mark)

---

3 Which species does **not** contain a total of 16 neutrons?

- ☒ **A** a molecule of ethene, $^{12}C_2{}^{1}H_4$
- ☒ **B** a molecule of oxygen, $^{16}O_2$
- ☒ **C** an atom of silicon, ^{30}Si
- ☒ **D** an ion of sulfur, $^{32}S^{2-}$

(Total for Question 3 = 1 mark)

---

2 What is the concentration of hydroxide ions in a solution containing 5.00 g of $Ba(OH)_2$ in 250 cm^3?

[M_r $Ba(OH)_2$ = 171.3]

- ☒ **A** 0.0292 mol dm^{-3}
- ☒ **B** 0.0584 mol dm^{-3}
- ☒ **C** 0.1168 mol dm^{-3}
- ☒ **D** 0.2335 mol dm^{-3}

(Total for Question 2 = 1 mark)

7 This question is about the thermal decomposition of calcium nitrate.

$$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$$

What volume of gas is produced by the complete decomposition of 0.050 mol of calcium nitrate at room temperature and pressure (r.t.p.)?

[Molar volume of a gas at r.t.p. = 24 $dm^3 mol^{-1}$]

☒ **A** 600 cm^3

☒ **B** 1.20 dm^3

☒ **C** 3.00 dm^3

☒ **D** 6.00 dm^3

(Total for Question 7 = 1 mark)

6 Which oxide of nitrogen contains 30% nitrogen by mass?

[A_r values: N = 14.0 O = 16.0]

☒ **A** NO

☒ **B** NO_2

☒ **C** N_2O

☒ **D** N_2O_3

(Total for Question 6 = 1 mark)

6 The electronic configurations of the atoms of four elements are shown.

What is the electronic configuration of the atom of element which has the **lowest** first ionisation energy?

☒ **A** $1s^2 2s^2 2p^6 3s^2$

☒ **B** $1s^2 2s^2 2p^6 3s^2 3p^1$

☒ **C** $1s^2 2s^2 2p^6 3s^2 3p^2$

☒ **D** $1s^2 2s^2 2p^6 3s^2 3p^3$

(Total for Question 6 = 1 mark)

12 Which cation would be the most polarising?

		Radius	Charge
☒	**A**	small	large
☒	**B**	small	small
☒	**C**	large	small
☒	**D**	large	large

(Total for Question 12 = 1 mark)

16: How many hydrogen atoms are in 14 g of methane?

[$L = 6.02 \times 10^{23}$]

- ☒ **A** 5.268×10^{23}
- ☒ **B** 6.880×10^{23}
- ☒ **C** 2.107×10^{24}
- ☒ **D** 2.752×10^{24}

(Total for Question 16 = 1 mark)

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11 Which row of the table shows properties consistent with the type of bonding shown?

		Bonding	Solubility in water	Melting temperature	Electrical conductivity of solid
☒	**A**	ionic	soluble	high	poor
☒	**B**	ionic	soluble	low	good
☒	**C**	metallic	soluble	low	good
☒	**D**	metallic	insoluble	high	poor

(Total for Question 11 = 1 mark)

2 How many moles of **ions** are there in 40 cm^3 of a solution of 0.050 mol dm^{-3} magnesium nitrate, $Mg(NO_3)_2$?

☒ **A** 0.0020 mol

☒ **B** 0.0040 mol

☒ **C** 0.0060 mol

☒ **D** 0.0080 mol

(Total for Question 2 = 1 mark)

3 A water molecule, containing the isotopes of hydrogen and oxygen, hydrogen-1 and oxygen-16, has a mass of 2.9908×10^{-23} g.

What is the mass of an atomic mass unit (amu) measured in grams?

[A_r values: oxygen-16 = 15.995 amu hydrogen-1 = 1.0080 amu]

☒ **A** 6.0185×10^{23}

☒ **B** 6.0221×10^{23}

☒ **C** 1.6605×10^{-24}

☒ **D** 1.6616×10^{-24}

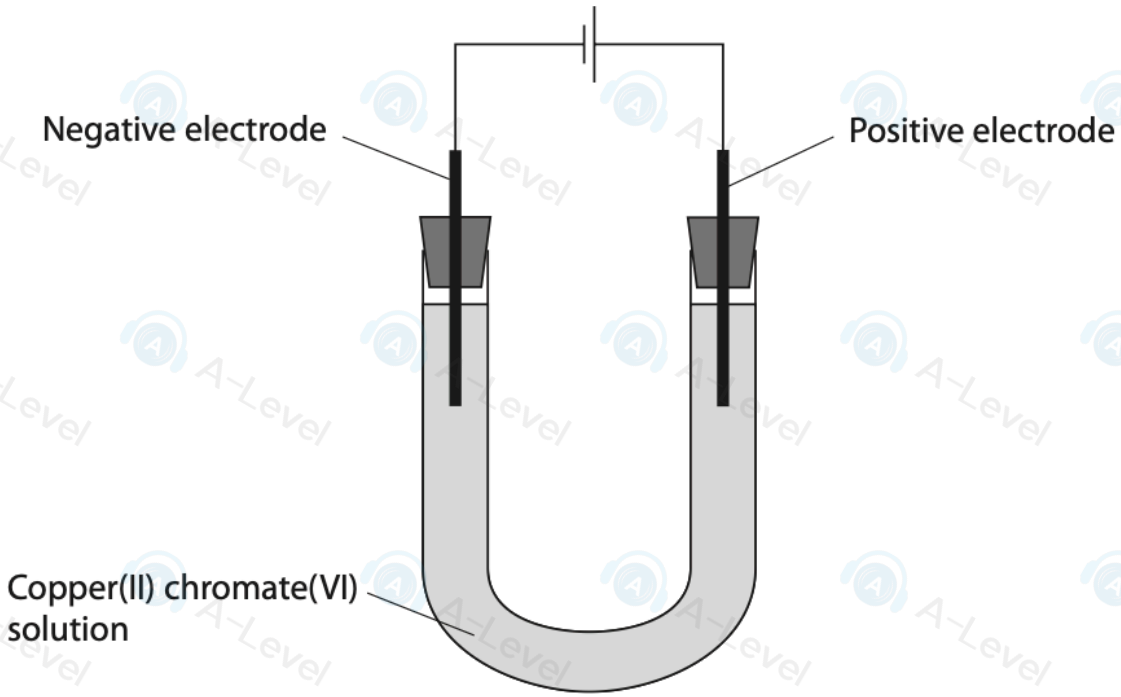
(Total for Question 3 = 1 mark)

6 How many neutrons and electrons are there in $^{190}_{79}Au^{2+}$?

	Neutrons	Electrons
☒ **A**	111	77
☒ **B**	111	81
☒ **C**	190	79
☒ **D**	190	77

(Total for Question 6 = 1 mark)

7 A direct electrical current was passed through a green solution of copper(II) chromate(VI) in the apparatus shown.



Which colours would be seen at each electrode after several minutes?

	Negative electrode	Positive electrode
☒ **A**	blue	green
☒ **B**	green	blue
☒ **C**	blue	yellow
☒ **D**	yellow	blue

(Total for Question 7 = 1 mark)

1 The first ionisation energies of four successive elements in the Periodic Table are shown.

Element	P	Q	R	S
First ionisation energy / kJ mol^{-1}	1251	1521	419	590

(a) Which element has atoms with a full outer shell of electrons?

- ☒ **A** element P
- ☒ **B** element Q
- ☒ **C** element R
- ☒ **D** element S

(b) Which element could be X in a gaseous covalent compound with the formula HX?

- ☒ **A** element P
- ☒ **B** element Q
- ☒ **C** element R
- ☒ **D** element S

(c) Which element could be Y in an ionic compound with the formula YF_2?

- ☒ **A** element P
- ☒ **B** element Q
- ☒ **C** element R
- ☒ **D** element S

(d) Which element has atoms with the largest atomic radius?

- ☒ **A** element P
- ☒ **B** element Q
- ☒ **C** element R
- ☒ **D** element S

(Total for Question 1 = 4 marks)

3 The formula of calcium carbide is CaC_2.

(a) What is the formula of the carbide ion?

(1)

☒ **A** C_2^-

☒ **B** C_2^+

☒ **C** C_2^{2-}

☒ **D** C_2^{2+}

(b) Excess calcium carbide and 10 g of water react to form the hydrocarbon ethyne, C_2H_2.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

What is the mass of ethyne that forms, assuming a yield of 100 %?

[M_r values: $H_2O = 18.0$ $C_2H_2 = 26.0$]

(1)

☒ **A** 7.22 g

☒ **B** 14.4 g

☒ **C** 23.4 g

☒ **D** 28.9 g

(Total for Question 3 = 2 marks)

20: This question is about carbon dioxide.

(a) According to data from 2021, there are 415 ppm of carbon dioxide in the atmosphere by volume.

Calculate the moles of carbon dioxide present in 1.00 m^3 of air at 20.0 °C and 101 kPa.

[Ideal gas equation $pV = nRT$
$R = 8.31\ J\ mol^{-1}\ K^{-1}$]

(4)

(b) Dodecane $C_{12}H_{26}$, is found in kerosene and forms carbon dioxide during its complete combustion.

(i) State what is meant by complete combustion.

(1)

.....

.....

(ii) Write a balanced equation for the complete combustion of dodecane, $C_{12}H_{26}$.

Include state symbols.

(2)

(iii) Kerosene is used as aeroplane fuel. A jet plane can carry a maximum of 800 passengers and uses 11 400 dm^3 of fuel per hour.

Calculate the mass, in kg, of carbon dioxide emitted from the engine per passenger on a full flight from Sydney to Hong Kong, flight time 9 hours 15 minutes.

Give your answer to three significant figures.
[Assume kerosene consists solely of $C_{12}H_{26}$

Density of dodecane = 0.749 g cm^{-3}]

(6)

(iv) The formula $C_{12}H_{26}$ represents many isomers, including six diethyloctanes.
The names of four of these diethyloctanes are

3,3-diethyloctane, 3,4-diethyloctane, 3,5-diethyloctane,
3,6-diethyloctane.

Draw the **skeletal** formulae of the remaining two diethyloctanes.

(2)

(Total for Question 20 = 15 marks)

23 Oxygen is vital in the treatment of respiratory diseases. Oxygen is traditionally produced by the fractional distillation of air.

(a) Suggest **one** difference between the fractional distillation of air and of crude oil.

(1)

.....

.....

(b) Hospital patients sometimes need to breathe air with a higher than normal concentration of oxygen.
The oxygen concentration can be increased to 90% by passing dry air through a tube filled with zeolite which adsorbs most of the nitrogen.

(i) Dry air contains 21.0% oxygen by volume.
The average human breath has a volume of 500 cm^3.

Calculate the volume of air, in dm^3, that would have to pass over the zeolite to obtain 500 cm^3 of gas containing 90% oxygen by volume.

(2)

(ii) Nitrogen molecules bind to zeolite using their outer electrons.

Draw a dot-and-cross diagram of the bonding in a nitrogen molecule.
Show outer electrons only.

(2)

17 Sodium hydroxide can be obtained as a hydrate, $NaOH \cdot xH_2O$.
When heated, the water of crystallisation is lost, leaving anhydrous sodium hydroxide, NaOH, as shown in the equation.

$$NaOH \cdot xH_2O \rightarrow NaOH + xH_2O$$

An experiment was carried out to determine the value of x in $NaOH \cdot xH_2O$.

Procedure

Step **1** Weigh and record the mass of a clean, dry crucible.

Step **2** Add approximately 1.0 g of $NaOH \cdot xH_2O$ to the crucible and record the mass.

Step **3** Heat the crucible and its contents until a constant mass has been reached.

Step **4** After allowing to cool, reweigh the crucible and the anhydrous solid.

Step **5** Calculate and record the mass of the anhydrous solid.

Repeat Steps **1** to **5** using a different mass of the hydrated sodium hydroxide.

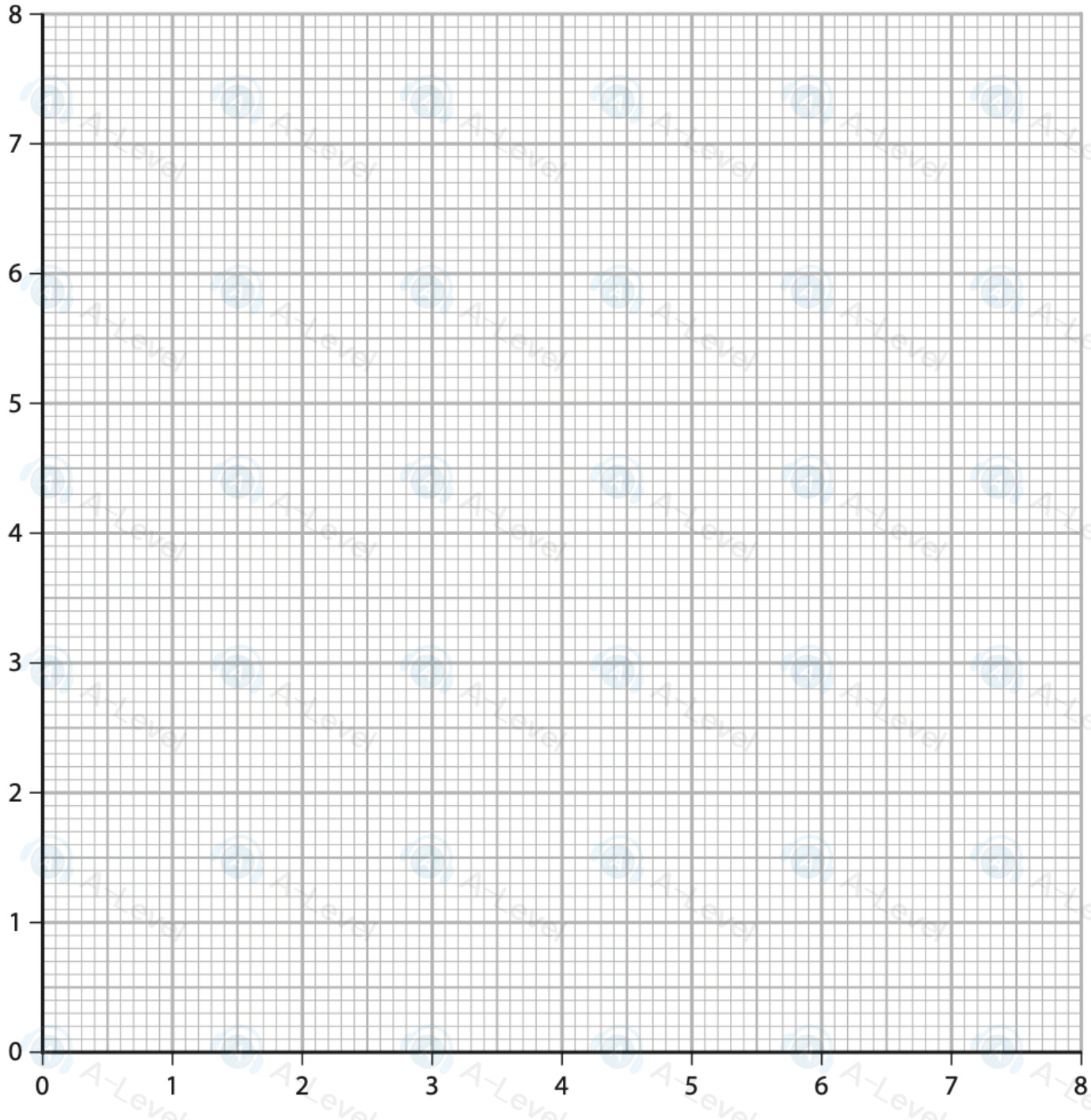
Results

Mass of $NaOH \cdot xH_2O$ / g	Mass of NaOH / g
1.00	0.69
2.10	1.45
3.50	2.41
4.90	3.38
6.60	4.55
8.00	5.52

(a) (i) Complete a graph of the results by

- plotting the points
- labelling the axes
- including a straight line of best fit.

(3)



(ii) Use your graph to determine the mass of $NaOH \cdot xH_2O$ needed to form 4.0 g of NaOH. You must show your working on the graph.

(1)

(iii) Calculate the value of x in $NaOH \cdot xH_2O$ using your answer to (a)(ii) and the equation for the reaction.

$$NaOH \cdot xH_2O \rightarrow NaOH + xH_2O$$

(3)

(b) Sodium hydroxide also forms a heptahydrate, $NaOH \cdot 7H_2O$.

Calculate the mass of this heptahydrate needed to make 250 cm^3 of a solution of sodium hydroxide of concentration 0.150 mol dm^{-3}.

(2)