

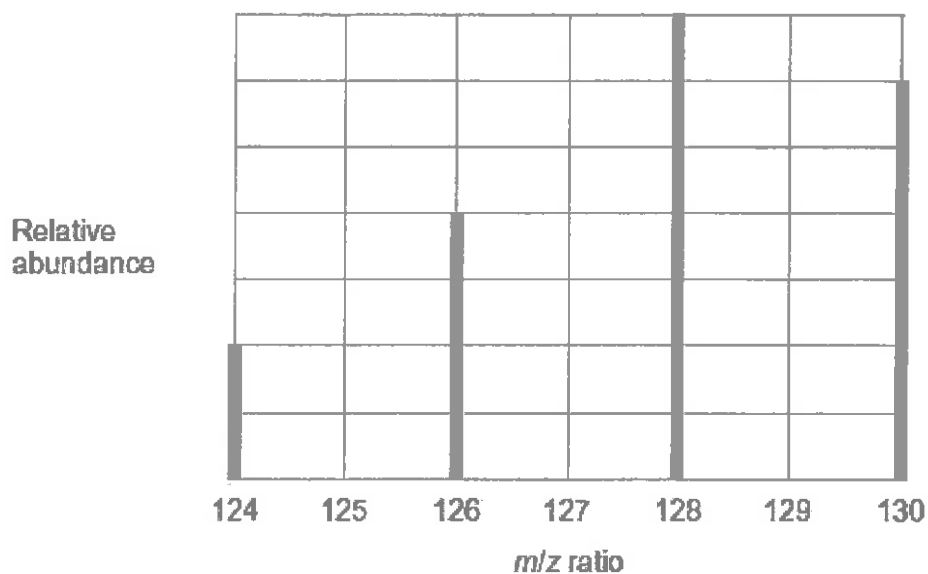
**Q1.** Tellurium is the element with atomic number of 52

- (a) Using information from the Periodic Table, complete the electron configuration of tellurium.

[Kr] .....

(1)

- (b) The mass spectrum of a sample of tellurium is shown in the graph.



- (i) Use the graph to calculate the relative atomic mass of this sample of tellurium. Give your answer to one decimal place.

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(3)

- (ii) Suggest what might cause the relative atomic mass of this sample to be different from the relative atomic mass given in the Periodic Table.

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(1)

(c) Write an equation for the reaction that occurs when a tellurium ion hits the detector.

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(1)

(d) State the  $m / z$  value of the ions that produce the biggest current at the detector when the spectrum in the graph is recorded.  
Give a reason for your answer.

$m / z$  value .....

Reason .....

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(2)

(e) The mass spectrum of tellurium also has a small peak at  $m / z = 64$

Explain the existence of this peak.

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(2)

(f) Predict whether the atomic radius of  $^{124}\text{Te}$  is larger than, smaller than or the same as the atomic radius of  $^{130}\text{Te}$   
Explain your answer.

Atomic radius of  $^{124}\text{Te}$  compared to  $^{130}\text{Te}$  .....

Explanation .....

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(2)  
(Total 12 marks)

**Q2.** This question is about the elements in Period 3 of the Periodic Table.

- (a) State the element in Period 3 that has the highest melting point.  
Explain your answer.

Element .....

Explanation .....

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**(3)**

- (b) State the element in Period 3 that has the highest first ionisation energy.  
Explain your answer.

Element .....

Explanation .....

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**(3)**

- (c) Suggest the element in Period 3 that has the highest electronegativity value.

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**(1)**

- (d) Chlorine is a Period 3 element.  
Chlorine forms the molecules  $\text{ClF}_3$  and  $\text{CCl}_2$

- (i) Use your understanding of electron pair repulsion to draw the shape of  $\text{ClF}_3$   
and the shape of  $\text{CCl}_2$   
Include any lone pairs of electrons that influence the shape.

Shape of  $\text{ClF}_3$

Shape of  $\text{CCl}_2$



**Q4.** Some airbags in cars contain sodium azide ( $\text{NaN}_3$ ).

- (a) Sodium azide is made by reacting dinitrogen monoxide gas with sodium amide ( $\text{NaNH}_2$ ) as shown by the equation.



Calculate the mass of sodium amide needed to obtain 550 g of sodium azide, assuming there is a 95.0% yield of sodium azide.  
Give your answer to 3 significant figures.

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(5)

- (b) If a car is involved in a serious collision, the sodium azide decomposes to form sodium and nitrogen as shown in the equation.



The nitrogen produced then inflates the airbag to a volume of  $7.50 \times 10^{-2} \text{ m}^3$  at a pressure of 150 kPa and temperature of 35 °C.

Calculate the minimum mass of sodium azide that must decompose.  
(The gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ )

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(6)

- (c) Sodium azide is toxic. It can be destroyed by reaction with an acidified solution of nitrous acid (HNO<sub>2</sub>) as shown in the equation.



- (i) A 500 cm<sup>3</sup> volume of the nitrous acid solution was used to destroy completely 150 g of the sodium azide.

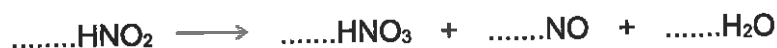
Calculate the concentration, in mol dm<sup>-3</sup>, of the nitrous acid used.

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(3)

- (ii) Nitrous acid decomposes on heating.

Balance the following equation for this reaction.



(1)

- (d) Sodium azide has a high melting point.

Predict the type of bonding in a crystal of sodium azide.  
Suggest why its melting point is high.

Type of bonding .....

Reason for high melting point .....

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(3)

- (e) The azide ion has the formula  $\text{N}_3^-$ .
- (i) The azide ion can be represented as  $\text{N} \equiv \text{N} - \text{N}^-$ .  
One of these bonds is a co-ordinate bond.

On the following diagram, draw an arrowhead on one of the bonds to represent the direction of donation of the lone pair in the co-ordinate bond.



(1)

- (ii) Give the formula of a molecule that has the same number of electrons as the azide ion.

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(1)

- (iii) Which is the correct formula of magnesium azide?

Tick (✓) **one** box.

$\text{Mg}_3\text{N}$

$\text{MgN}$

$\text{MgN}_6$

$\text{Mg}_3\text{N}_2$

(1)

(Total 21 marks)

- Q5.(a) Write an equation, including state symbols, for the reaction with enthalpy change equal to the standard enthalpy of formation for  $\text{CF}_4(\text{g})$ .

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(1)

(b) Explain why  $\text{CF}_4$  has a bond angle of  $109.5^\circ$ .

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(2)

(c) Table 1 gives some values of standard enthalpies of formation ( $\Delta_f H^\ominus$ ).

Table 1

Substance	$\text{F}_2(\text{g})$	$\text{CF}_4(\text{g})$	$\text{HF}(\text{g})$
$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	0	-680	-269

The enthalpy change for the following reaction is  $-2889 \text{ kJ mol}^{-1}$ .



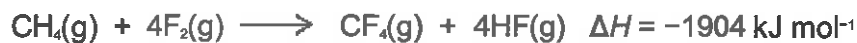
Use this value and the standard enthalpies of formation in Table 1 to calculate the standard enthalpy of formation of  $\text{C}_2\text{H}_6(\text{g})$ .

Standard enthalpy of formation of  $\text{C}_2\text{H}_6(\text{g}) = \dots\dots\dots \text{kJ mol}^{-1}$

(3)



(d) Methane reacts violently with fluorine according to the following equation.



Some mean bond enthalpies are given in Table 2.

Table 2

Bond	C-H	C-F	H-F
Mean bond enthalpy / kJ mol <sup>-1</sup>	412	484	562

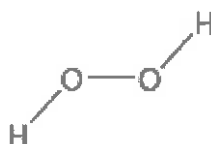
A student suggested that one reason for the high reactivity of fluorine is a weak F-F bond.

Is the student correct? Justify your answer with a calculation using these data.

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(4)  
(Total 10 marks)

Q6.A hydrogen peroxide molecule can be represented by the structure shown.



(a) Suggest a value for the H-O-O bond angle.

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(1)

(b) Hydrogen peroxide dissolves in water.

(i) State the strongest type of interaction that occurs between molecules of hydrogen peroxide and water.

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(1)

(ii) Draw a diagram to show how one molecule of hydrogen peroxide interacts with one molecule of water.  
Include all lone pairs and partial charges in your diagram.

(3)

(c) Explain, in terms of electronegativity, why the boiling point of  $\text{H}_2\text{S}_2$  is lower than  $\text{H}_2\text{O}_2$ .

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(2)

(Total 7 marks)

**Q7.(a)** Calcium phosphate reacts with aqueous nitric acid to produce phosphoric acid and calcium nitrate as shown in the equation.



- (i) A 7.26 g sample of calcium phosphate reacted completely when added to an excess of aqueous nitric acid to form 38.0 cm<sup>3</sup> of solution.

Calculate the concentration, in mol dm<sup>-3</sup>, of phosphoric acid in this solution.  
Give your answer to 3 significant figures.

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**(5)**

- (ii) Calculate the percentage atom economy for the formation of calcium nitrate in this reaction.  
Give your answer to 1 decimal place.

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**(2)**

- (b) Write an equation to show the reaction between calcium hydroxide and phosphoric acid to produce calcium phosphate and water.

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(1)

- (c) Calcium dihydrogenphosphate can be represented by the formula  $\text{Ca}(\text{H}_2\text{PO}_4)_x$ , where  $x$  is an integer.  
A 9.76 g sample of calcium dihydrogenphosphate contains 0.17 g of hydrogen, 2.59 g of phosphorus and 5.33 g of oxygen.

Calculate the empirical formula and hence the value of  $x$ .  
Show your working.

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(4)

(Total 12 marks)

**Q8.** Which one of the following does **not** have a pair of s electrons in its highest filled electron energy sub-level?

- A H<sup>-</sup>
- B Mg
- C P<sup>3-</sup>
- D Ar

(Total 1 mark)

**Q9.** Assuming that chlorine exists as two isotopes, and that hydrogen and carbon exist as one isotope each, how many molecular ion peaks will be shown in the mass spectrum of  $C_4H_6Cl_4$ ?

- A 2
- B 3
- C 4
- D 5

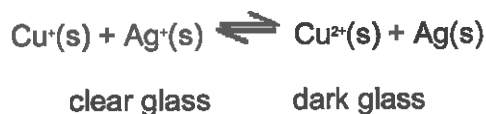
(Total 1 mark)

**Q10.** An atom in which the number of protons is greater than the number of neutrons is

- A  $^{234}\text{U}$
- B  $^6\text{Li}$
- C  $^3\text{He}$
- D  $^2\text{H}$

(Total 1 mark)

**Q11.** Photochromic glass contains silver ions and copper ions. A simplified version of a redox equilibrium is shown below. In bright sunlight the high energy u.v. light causes silver atoms to form and the glass darkens. When the intensity of the light is reduced the reaction is reversed and the glass lightens.



Which one of the following is a correct electron arrangement?

- A  $\text{Cu}^+$  is  $[\text{Ar}]3d^94s^1$
- B  $\text{Cu}$  is  $[\text{Ar}]3d^{10}4s^2$
- C  $\text{Cu}^{2+}$  is  $[\text{Ar}]3d^94s^1$
- D  $\text{Cu}^+$  is  $[\text{Ar}]3d^{10}$

(Total 1 mark)

**Q12.** Which change requires the largest amount of energy?

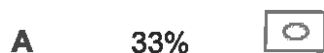


(Total 1 mark)

**Q13.** An ester is hydrolysed as shown by the following equation.



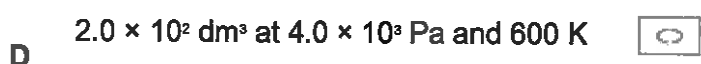
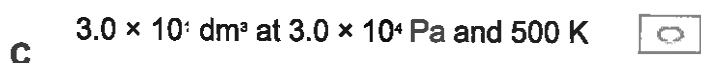
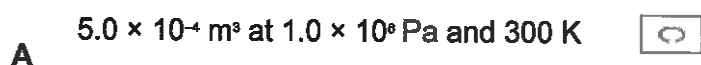
What is the percentage yield of RCOOH when 0.50 g of RCOOH ( $M_r = 100$ ) is obtained from 1.0 g of RCOOR' ( $M_r = 150$ )?



(Total 1 mark)

**Q14.** Which of these samples of gas contains the largest number of molecules?

The gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ .



(Total 1 mark)

Q15. Which of the following contains the most chloride ions?

- A 10 cm<sup>3</sup> of  $3.30 \times 10^{-2}$  mol dm<sup>-3</sup> aluminium chloride solution
- B 20 cm<sup>3</sup> of  $5.00 \times 10^{-2}$  mol dm<sup>-3</sup> calcium chloride solution
- C 30 cm<sup>3</sup> of  $3.30 \times 10^{-2}$  mol dm<sup>-3</sup> hydrochloric acid
- D 40 cm<sup>3</sup> of  $2.50 \times 10^{-2}$  mol dm<sup>-3</sup> sodium chloride solution

(Total 1 mark)

Q16. Which one of the following has a shape which is **not** influenced by a lone pair of electrons?

- A CH<sub>3</sub>OH
- B H<sub>2</sub>F<sup>+</sup>
- C BF<sub>3</sub>
- D NF<sub>3</sub>

(Total 1 mark)

Q17. Which one of the following bond polarities is **not** correct?

- A  $\overset{\delta+}{\text{C}}-\overset{\delta-}{\text{H}}$  in ethane
- B  $\overset{\delta+}{\text{C}}-\overset{\delta-}{\text{Br}}$  in bromoethane
- C  $\overset{\delta+}{\text{C}}-\overset{\delta-}{\text{O}}$  in ethanol
- D  $\overset{\delta+}{\text{C}}=\overset{\delta-}{\text{O}}$  in ethanal

(Total 1 mark)

**Q18.**When ethanamide ( $\text{CH}_3\text{CONH}_2$ ) burns in oxygen the carbon is converted into carbon dioxide, the hydrogen is converted into water and the nitrogen forms nitrogen gas.

Substance	ethanamide	carbon dioxide	water
Enthalpy of formation ( $\Delta H_f^\ominus$ ) / $\text{kJ mol}^{-1}$	-320	-394	-286

Using the data above, which one of the following is a correct value for the enthalpy of combustion of ethanamide?

- A -1823  $\text{kJ mol}^{-1}$
- B -1183  $\text{kJ mol}^{-1}$
- C -1000  $\text{kJ mol}^{-1}$
- D -360  $\text{kJ mol}^{-1}$

(Total 1 mark)