

90780

Level 3 Chemistry, 2008

90780 Describe properties of particles and thermochemical principles

Interactive paper

Credits: Five

You should answer ALL the questions in this paper.

Type your answers in the fields provided. Copy and paste any special characters needed from the box at the top of each page. Use the *Comment and Markup* tools to draw diagrams, circle options and so on. When you have finished, click the Show Answers button at the end of the paper. This will reveal the answers and marking schedule, and boxes for you to enter the grades (N, A, M or E). As you mark the paper your totals and overall performance will appear in the boxes below.

<i>For Assessor's use only</i>		
Achievement Criteria		
Achievement	Achievement with Merit	Achievement with Excellence
Describe aspects of organic chemistry.	Explain and apply aspects of organic chemistry.	Discuss aspects of organic chemistry.
Overall Level of Performance		

You are advised to spend 45 minutes answering the questions in this booklet.

QUESTION ONE: ATOMS, IONS and THEIR PROPERTIES

(a) (i) Place the following species in order of increasing size: H, H⁺, H⁻.

< <

(ii) Justify your answer.

1(a)(i)	H ⁺ < H < H ⁻	A Correct order AND 1 reason.
(ii)	<ul style="list-style-type: none"> • because H⁺ has no electron / has lost a shell / has lost an electron / is a bare proton • because H⁻ has more electrons: causing electron repulsions. 	M Correct order AND BOTH reasons.

(b) Write the electron configuration using *s*, *p*, *d* notation for:

Sc

Br⁻

Mn²⁺

(b)	<ul style="list-style-type: none"> • Sc 1s²2s²2p⁶3s²3p⁶4s²3d¹ / [Ar] 3d¹4s² • Br⁻ 1s²2s²2p⁶3s²3p⁶4s²3d¹⁰4p⁶ / [Ar] 3d¹⁰4s²4p⁶ / [Kr] • Mn²⁺ 1s²2s²2p⁶3s²3p⁶3d⁵ / [Ar] 3d⁵ 	A 2 correct M 3 correct
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(c) Account for the following:

(i) A bromine atom, Br, has more electrons than a scandium atom, Sc, but its radius is smaller.

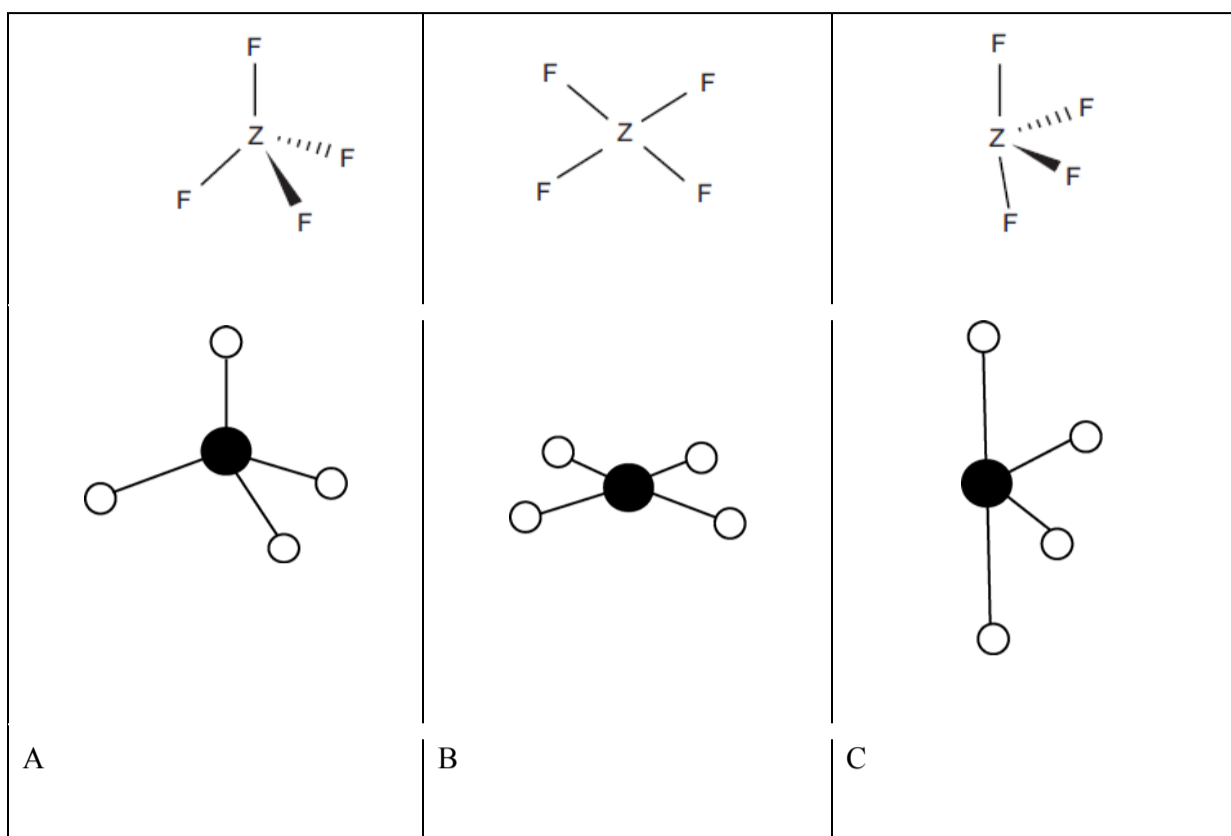
(ii) A bromine atom, Br, is smaller than a scandium atom, Sc, but its ionisation energy is larger.

(c)(i)	<ul style="list-style-type: none"> • Br has greater nuclear charge / no. of protons • But same number of shells / energy levels OR • Br has greater effective nuclear charge (ENC) AND • which causes stronger attraction to the electrons 	A Nuclear charge / effective nuclear charge (ENC) is greater. M 1 explanation is complete
(ii)	<ul style="list-style-type: none"> • Br electrons closer to the nucleus / Br atom has smaller radius / Br atom is smaller OR • Br atom has greater nuclear charge / number of protons • But same number of shells / energy levels OR • Br atom has greater ENC than Sc, AND • which causes stronger attraction to the electrons 	E BOTH explanations complete

QUESTION TWO : MOLECULES, IONS AND THEIR PROPERTIES

(a) The drawings below are three possible shapes for a molecule ZF_4 , where 'Z' represents the central element. 'Z' has lower electronegativity than F.

Name the shapes represented by the three diagrams.



2 (a)	(A) tetrahedral (B) square planar (C) distorted tetrahedral / seesaw	A 2 correct
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(b) Explain why C is the only shape that can give rise to a polar molecule for ZF_4 .

2 (b)	<ul style="list-style-type: none"> • A and B: symmetric • Polarities / dipoles / the effect of the polar bonds: cancel OR Centres of positive and negative charge coincide OR Symmetric / even distribution of charge about central atom. AND • C: asymmetric • Polarities reinforce OR centres of positive and negative don't coincide OR Asymmetric/uneven distribution of charge about central atom. OR • C: asymmetric arrangement of polar bonds • causes charge separation. 	<ul style="list-style-type: none"> A Recognises different symmetries of molecules OR 1 type explained M Explanation complete
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(c) Draw the Lewis diagram for the ion BrF_4^- .

2 (c)		A Diagram correct
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(d) (i) Choose the structure for the BrF_4^- ion from those pictured in part (a), on the previous page.

(ii) Give a reason for your answer.

(iii) Circle the element, from the following list, which would be the central element Z in a molecule ZF_4 that has shape C (see part(a)).

Be C Se Si Xe

Justify your answer.

<p>(d) (i)(ii)</p>	<ul style="list-style-type: none"> • Square planar OR B (or follow on) • electron pairs repel • 6 electron clouds / pairs • 2 non-bonding / 4 bonding 	<p>A Correct choice of shape (i) OR atom (iii) linked to number of of electron clouds / pairs on central atom i.e. square planar – 6 charge clouds</p>
<p>(iii)</p>	<ul style="list-style-type: none"> • Se • Shape requires, 5 electron pairs / 4 bonding pairs and 1 non-bonding pair • 4 Se electrons shared with F's / 4 F electrons shared with Se (may include structure as part of evidence for these) • 6 valence electrons on Z <p>OR</p> <ul style="list-style-type: none"> • Se • Need 5 electron pairs / clouds on central atom so total valence electrons must be 34. Total electrons from 4 F atoms is 28, (may include structure as part of evidence for these) • so central atom must have 6 valence electrons <p>OR</p> <ul style="list-style-type: none"> • Se • by elimination of other possibilities <p>OR</p> <p>correct structure (but relevant supporting text must be correct)</p>	<p>Se – 5 charge clouds</p> <p>Note: follow on: can be from 2(a) if structure (b) has been incorrectly named OR from an incorrect structure for 2(c)</p> <p>M Correct choice of shape AND atom linked to number of electron clouds / pairs on central atoms. OR (d)(i)(ii) correct OR (d)(iii) correct</p> <p>E All correct</p>

(e) Account for the difference in the boiling points for the following pairs of compounds by comparing the main forces between the molecules in each case.

(i)

	Boiling point / °C	Molar mass / g mol ⁻¹
Compound A, CH ₃ OH	65	32.0
Compound B, CH ₃ SH	6	48.1

(ii)

	Boiling point / °C	Molar mass / g mol ⁻¹
Compound C, $\begin{array}{c} \text{H}_3\text{C}-\text{C}-\text{CH}_3 \\ \parallel \\ \text{O} \end{array}$	58	58.0
Compound D, $\begin{array}{c} \text{H}_3\text{C}-\text{CH}-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$	-12	58.0

(e) (i)	<ul style="list-style-type: none"> • A has hydrogen bonding AND permanent dipole (PD) / temporary dipole (TD) : attractions • B has PD / TD : attractions • Hydrogen bonding is a stronger attraction 	<p>A Identifies two of the following inter-molecular relationships.</p> <p>A → H bonding B → TD or PD C → PD D → TD</p>
(ii)	<ul style="list-style-type: none"> • C has PD / TD attractions : stronger • D has TD attractions <p>(attractions = force = bond)</p>	<p>M All of A → H bonding B → TD or PD attractions C → PD attractions D → TD attractions AND discussion of relative bond strengths OR One pair as above plus a third relevant force.</p> <p>E All of A → H bonding B → TD or PD attractions C → PD attractions D → TD attractions AND discussion of relative bond strengths AND a fifth relevant force.</p>

QUESTION THREE : ENTHALPY CHANGES

(a) Urea, $(\text{NH}_2)_2\text{CO}$, which is a white crystalline solid, is widely used as a fertiliser.

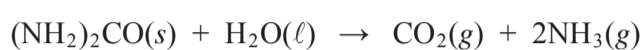
Write the equation for which the enthalpy change is:

(i) the enthalpy of formation, $\Delta_f H^\circ$, for urea

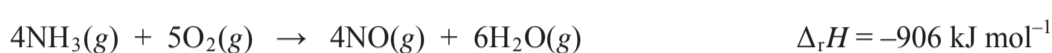
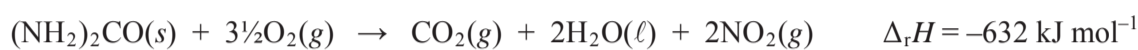
(ii) the enthalpy of fusion, $\Delta_{\text{fus}} H^\circ$, for urea

3 (a)	(i) $\frac{1}{2} \text{O}_2(g) + 2\text{H}_2(g) + \text{N}_2(g) + \text{C}(s) \rightarrow (\text{NH}_2)_2\text{CO}(s)$ (ii) $(\text{NH}_2)_2\text{CO}(s) \rightarrow (\text{NH}_2)_2\text{CO}(l)$	A (i) OR (ii) correct (including states) M Both correct (including states)
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(b) Urea breaks down in moist soil into carbon dioxide and ammonia.



Calculate the enthalpy change for this reaction, $\Delta_r H$, using the information below.



(b)	Desired Equation = EqA $- \frac{1}{2}$ EqB $- 2$ EqC $+ 3$ EqD $(\text{NH}_2)_2\text{CO}(s) + 3\frac{1}{2}\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(l) + 2\text{NO}_2(g)$ $\Delta_r H = -632$ $2\text{NO}(g) + 3\text{H}_2\text{O}(g) \rightarrow 2\text{NH}_3(g) + 2\frac{1}{2}\text{O}_2(g) \quad \Delta_r H = +453$ $2\text{NO}_2(g) \rightarrow 2\text{NO}(g) + \text{O}_2(g) \quad \Delta_r H = +114$ $3\text{H}_2\text{O}(l) \rightarrow 3\text{H}_2\text{O}(g) \quad \Delta_{\text{vap}} H = +123$ <hr/> $(\text{NH}_2)_2\text{CO}(s) + \text{H}_2\text{O}(l) \rightarrow \text{CO}_2(g) + 2\text{NH}_3(g)$ $\Delta_r H = \Delta_r H(\text{EqA}) - \frac{1}{2}\Delta_r H(\text{EqB}) - 2\Delta_r H(\text{EqC}) + 3\Delta_{\text{vap}} H(\text{EqD})$ $= -632 + \frac{1}{2}(906) + 2 \times 57 + 3 \times 41$ $= -632 + 453 + 114 + 123$ $= 58 \text{ kJ mol}^{-1}$	A Reactants and products correctly identified for all 4 equations with states for H_2O OR Calculation correct with one error. M Numerical value correct E Numerical value correct with sign and unit(s).
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