

**2010:1**

- (a) Complete the following table.

Symbol	Electron configuration (s, p, d notation)
Ca	
Cr	
Mn <sup>2+</sup>	

- (b) Explain why calcium has only one oxidation state, other than zero, while manganese has several different oxidation states.
- (c) Match the atoms and ions to the radii given.  
Ca, Ca<sup>2+</sup>, Mn & 99 pm, 137 pm and 197 pm

**2009:1**

- (a) Write the electron configuration using s, p, d notation for:

Ca <sup>2+</sup>
Br
Fe <sup>2+</sup>

- (b) Account for the fact that compounds containing Ca<sup>2+</sup> and Zn<sup>2+</sup> are not coloured, whereas compounds containing Fe<sup>2+</sup> are coloured.
- (c) Account for the differences in the atomic or ionic properties given below

(i)

Atom	Ionisation energy (kJ mol <sup>-1</sup> )
Ca	596
Br	1146

(ii)

Atom / ion	Radius (pm)
Br	114
Br <sup>-</sup>	196
I	133

**2008:1**

- (a) (i) Place the following species in order of increasing size: H, H<sup>+</sup>, H<sup>-</sup>.
- (ii) Justify your answer.

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

Sc
Br <sup>-</sup>
Mn <sup>2+</sup>

- (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.

**2007:1**

- (a) Write the electron configuration using s, p, d notation for:

K
P <sup>3-</sup>
Zn <sup>2+</sup>

- (b) Explain in terms of electron configuration why zinc sulfate, ZnSO<sub>4</sub>, forms a colourless solution, whereas copper sulfate, CuSO<sub>4</sub>, forms a blue solution.
- (c) Explain the difference between the radii of the following species.  
 (i) K atom and K<sup>+</sup> ion  
 (ii) P atom and P<sup>3-</sup> ion
- (d) Account for the differences in electronegativity values for nitrogen, potassium and arsenic.

Element	Electronegativity
Nitrogen, N	3.04
Potassium, K	0.82
Arsenic, As	2.18

**2006:1**

- (a) Compare the relative sizes of the Ca<sup>2+</sup> and Cl<sup>-</sup> ions, and explain the difference in their radii.
- (b) (i) Describe what is meant by “the first ionisation energy of chlorine”.  
 (ii) Place magnesium, calcium and chlorine atoms in order of increasing first ionisation energies (IE). Justify your answer in terms of the factors that affect ionisation energy.

Describe properties of particles & thermochemical principles (collated questions)

**2006:3**

- (a) Write the electron configuration for:  
Cr, Mn &  $\text{Mn}^{2+}$
- (b) Explain why manganese and chromium form a variety of different compounds and ions with oxygen.
- (c) Explain why most manganese and chromium compounds are coloured.

**2010:2**

- (a) Complete the table by:
- (i) drawing Lewis diagrams for the two molecules
  - (ii) drawing the shape of each molecule
  - (iii) giving the name of the shape of each molecule.

Molecule	$\text{SF}_4$	$\text{XeF}_4$
Lewis diagram		
Diagram of shape		
Name of shape		

- (b) Discuss the fact that although both  $\text{SF}_4$  and  $\text{XeF}_4$  have four bonds around the central atom, the molecules have different shapes and polarities.

**2009:2**

- (a) Complete the table below by drawing Lewis diagrams for the two molecules and writing the name that describes the shape of each molecule.

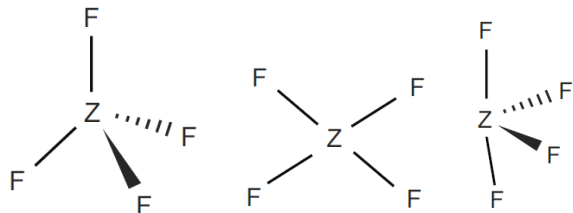
	$\text{BrF}_3$	$\text{SF}_6$
Lewis diagram		
Shape		

- (b) Compare the polarities of the two molecules,  $\text{BrF}_3$  and  $\text{SF}_6$ .

**2008:2 parts a - d**

- (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.



- (b) Explain why C is the only shape that can give rise to a polar molecule for  $ZF_4$ .
- (c) Draw the Lewis diagram for the ion  $BrF_4^-$ .
- (d) (i) Choose the structure for the  $BrF_4^-$  ion from those pictured in part (a). (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.

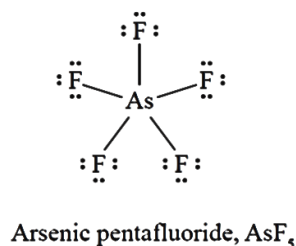
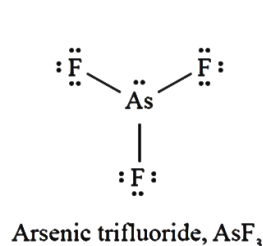
**2007:2**

- (a) Complete the table below by drawing Lewis diagrams for  $BrF_3$  and  $BrF_5$ , and naming their shape.

	$BrF_3$	$BrF_5$
(i) Lewis diagram		
(ii) Shape		

- (b) Discuss the polarities of  $AsF_3$  and  $AsF_5$  molecules. Your discussion should include:
- justification for the molecular shape and
  - relative electronegativities of the atoms within the molecule.

The Lewis structures for each molecule are shown below.



**2006:2**

(a) Complete the table below by:

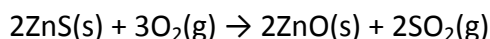
- (i) drawing Lewis diagrams for phosphorus trifluoride,  $\text{PF}_3$ , and tetrachloroiodide ion  $\text{ICl}_4^-$ ,  
 (ii) identifying the shape of  $\text{BF}_3$ ,  $\text{PF}_3$  and  $\text{ICl}_4^-$ .

		$\text{BF}_3$	$\text{PF}_3$	$\text{ICl}_4^-$
(i)	<b>Lewis diagram</b>	$  \begin{array}{c}  \text{:}\ddot{\text{F}}\text{---B---}\ddot{\text{F}}\text{:} \\    \\  \text{:}\ddot{\text{F}}\text{:}  \end{array}  $		
(ii)	<b>Shape</b>			

(b) Discuss reasons for the difference in the polarities of  $\text{BF}_3$  and  $\text{PF}_3$  molecules.

**2010:3**

- (a) (i) Write the equation for which the enthalpy change is the enthalpy of formation,  $\Delta_f H^\circ$ , for zinc oxide.  
 (ii) Zinc oxide is formed when zinc sulfide is heated in air.



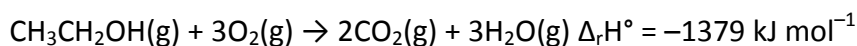
Calculate the enthalpy change,  $\Delta_r H^\circ$ , for this reaction, using the following data.

$$\Delta_f H^\circ (\text{ZnS(s)}) = -200 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ (\text{ZnO(s)}) = -348 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ (\text{SO}_2\text{(g)}) = -297 \text{ kJ mol}^{-1}$$

(b) The equation for the combustion of ethanol is:

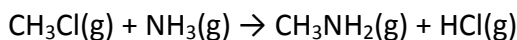


Calculate the bond enthalpy for the O–H bond using the enthalpy of the reaction above and the bond enthalpy data given below.

Bond	Bond enthalpy / $\text{kJ mol}^{-1}$
C–H	+ 412
C–O	+ 360
O=O	+ 496
C–C	+ 348
C=O	+ 743

**2009:3**

- (a) Calculate the enthalpy change for the reaction below using the bond enthalpy data in the table.



Bond	Bond enthalpy ( $\text{kJ mol}^{-1}$ )
C – H	414
C – Cl	339
N – H	391
C – N	286
H – Cl	431

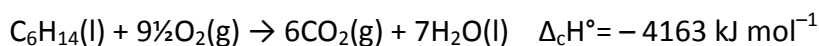
- (b) Define the term  $\Delta_{\text{vap}}H^\circ$ .

- (c) Justify the similarity in the  $\Delta_{\text{vap}}H^\circ$  of  $\text{CH}_3\text{Cl}$  and  $\text{CH}_3\text{NH}_2$ .

	$\Delta_{\text{vap}}H^\circ$ ( $\text{kJ mol}^{-1}$ )	Molar mass ( $\text{g mol}^{-1}$ )
$\text{CH}_3\text{Cl}$	22	50.5
$\text{CH}_3\text{NH}_2$	24	31.0

**2009:4**

- (a) Carbon dioxide and water are formed when hexane burns in oxygen.



Calculate the enthalpy of formation of hexane,  $\Delta_f H^\circ(\text{C}_6\text{H}_{14}, \text{l})$ .

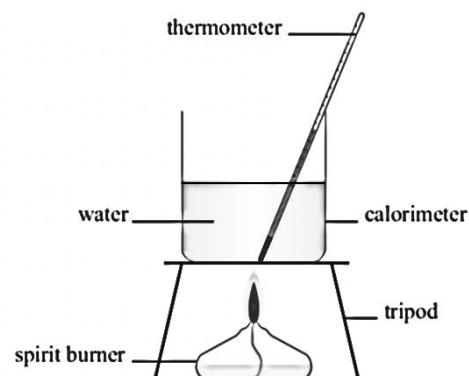
$$\Delta_f H^\circ(\text{CO}_2, \text{g}) = -393 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ(\text{H}_2\text{O}, \text{l}) = -286 \text{ kJ mol}^{-1}$$

- (b) The apparatus below was used to determine the enthalpy of combustion of hexane. When 0.400 g of hexane was burned in the spirit burner, the temperature of 150 g of water was found to increase from  $22^\circ\text{C}$  to  $39^\circ\text{C}$ . Calculate the experimental value of  $\Delta_c H$  ( $\text{C}_6\text{H}_{14}, \text{l}$ ).

$$M(\text{C}_6\text{H}_{14}) = 86.0 \text{ g mol}^{-1}$$

$$\text{specific heat capacity of water} = 4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$$



- (c) Account for the difference between the experimental value and the value given in part (a), AND suggest how this difference could be minimised.

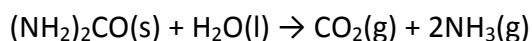
### 2008:3

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

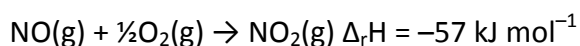
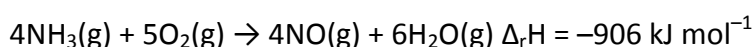
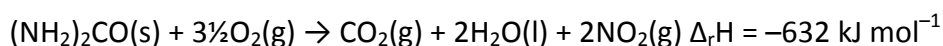
Write the equation for which the enthalpy change is:

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

- (b) Urea breaks down in moist soil into carbon dioxide and ammonia.

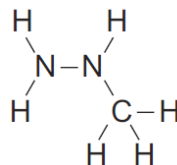


Calculate the enthalpy change for this reaction,  $\Delta_r H$ , using the information below.



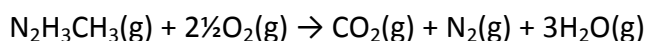
- (c) Methylhydrazine,  $\text{N}_2\text{H}_3\text{CH}_3$ , can be used as a fuel.

The structural formula for methylhydrazine is



- (i) Define the term bond enthalpy.

- (ii) Use the bond enthalpies given in the table below to calculate the energy released when one mole of methylhydrazine vapour is burned.



Bond	Bond enthalpy / $\text{kJ mol}^{-1}$	Bond	Bond enthalpy / $\text{kJ mol}^{-1}$
N–N	163	C=O	804
N–H	391	O–H	463
N–C	286	C–H	414
N≡N	941	O=O	498

### 2010:4

- (a) (i) Write the equation for which the enthalpy change is the enthalpy of fusion,  $\Delta_{\text{fus}} H^\circ$ , for zinc sulfide.  
(ii) Give a reason why  $\Delta_{\text{fus}} H^\circ$  is always greater than zero.
- (b) Ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) and propane ( $\text{CH}_3\text{CH}_2\text{CH}_3$ ) have similar molar masses but ethanol is a liquid at room temperature, while propane is a gas. Identify the types of intermolecular forces for each of these substances and explain why ethanol has a higher boiling point than propane.

- (c) Account for the difference in the boiling points of the two substances in the table below by comparing all the intermolecular forces.

Name	Structure	Boiling Point / °C
butan-1-ol	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	117.7
2-methylpropan-2-ol	$  \begin{array}{c}  \text{CH}_3 \\    \\  \text{CH}_3 - \text{C} - \text{CH}_3 \\    \\  \text{OH}  \end{array}  $	82.6

**2008: 2 part e**

- (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 <sup>-1</sup>
Compound A, CH <sub>3</sub> OH	65	32.0
Compound B, CH <sub>3</sub> SH	6	48.1

(ii)	Boiling point / °C	Molar mass / g mol <sup>-1</sup>
Compound C, $  \begin{array}{c}  \text{H}_3\text{C}-\text{C}-\text{CH}_3 \\     \\  \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

**2007:3**

- (a) The boiling points of HF, F<sub>2</sub> and HCl are given below.

Molecule	Boiling point (°C)
Hydrogen fluoride, HF	19.5
Fluorine, F <sub>2</sub>	-188.1
Hydrogen chloride, HCl	- 85.1

Discuss the different boiling points of hydrogen fluoride, fluorine and hydrogen chloride in terms of the relative strengths of the intermolecular forces between the particles involved.



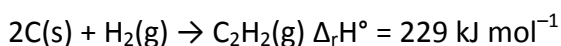
Describe properties of particles & thermochemical principles (collated questions)

- (b) Write the equation for the reaction that has an enthalpy change given by  $\Delta_f H^\circ(\text{HCl, g})$ .
- (c) (i) Calculate  $\Delta_f H^\circ(\text{HCl, g})$  using the following bond enthalpies
- (ii)  $\Delta_f H^\circ(\text{HBr, g})$  is  $-36.2 \text{ kJ mol}^{-1}$ .
- Calculate the heat produced by the formation of 50.0 g of HBr(g) from its elements in their standard states.

Bond	Bond enthalpy / $\text{kJ mol}^{-1}$
H–H	436
Cl–Cl	242
H–Cl	431

**2007: 4**

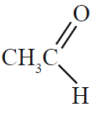
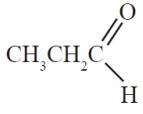
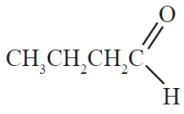
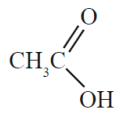
Calculate the heat of combustion of ethyne,  $\Delta_c H^\circ \text{C}_2\text{H}_2(\text{g})$ , from the following data:



$$\Delta_c H^\circ(\text{H}_2, \text{g}) = -285 \text{ kJ mol}^{-1} \quad \Delta_c H^\circ(\text{C, s}) = -393 \text{ kJ mol}^{-1}$$

**2006: 4**

Use the following information to answer the question below.

	ethanal	propanal	butanal	ethanoic acid
				
$\Delta_{\text{vap}} H / \text{kJ mol}^{-1}$	26	30	34	52

Discuss the trend in  $\Delta_{\text{vap}} H$  of the compounds in the table above in terms of the attractive forces between the particles and the factors affecting those forces.

**2006:5**

- (a) Write the equation for the reaction that has an enthalpy change equal to  $\Delta_c H^\circ(\text{H}_2, \text{g})$
- (b) Explain why  $\Delta_f H^\circ(\text{H}_2\text{O, l})$  is equal to  $\Delta_c H^\circ(\text{H}_2, \text{g})$ .
- (c) (i) Calculate the enthalpy of formation of water in the gas state,  $\Delta_f H^\circ(\text{H}_2\text{O, g})$ , using the following bond enthalpies.

Bond	Bond enthalpy / $\text{kJ mol}^{-1}$
H–H	436
O–H	463
O=O	498

(ii) The experimental value for  $\Delta_f H^\circ(\text{H}_2\text{O, l})$  is  $-286 \text{ kJ mol}^{-1}$ .

Using the information above, calculate the  $\Delta_{\text{vap}} H^\circ(\text{H}_2\text{O})$ , and also the heat required to vaporise 100 g of water.

- (d) Calculate  $\Delta_f H^\circ(\text{C}_2\text{H}_5\text{OH, l})$  using the following data.

$$\Delta_c H^\circ(\text{C}_2\text{H}_5\text{OH, l}) = -1367 \text{ kJ mol}^{-1} \quad \Delta_f H^\circ(\text{CO}_2, \text{g}) = -394 \text{ kJ mol}^{-1} \quad \Delta_f H^\circ(\text{H}_2\text{O, l}) = -286 \text{ kJ mol}^{-1}$$