

In 2004 the *particles* and *thermochemistry* topics were examined in two separate achievement standards (90697: Describe selected atomic, molecular and ionic properties, and 90699: Describe and use thermochemical principles). For 2006 those two standards have been combined in a new Chemistry 3.4 (90780: Describe properties of particles and thermochemical principles). Radiochemistry and some aspects of transition metal chemistry from the old 90697 are no longer included in the new standard.

This paper combines those questions from the two 2004 papers which are still relevant, with a new transition metals question.

Chemistry 3.4, 2004

90780 Describe properties of particles and thermochemical principles

Credits: Five

You should answer ALL the questions in this booklet.

Show all working for calculations.

If you need more space for any answer, add in extra pages and clearly number the question.

A periodic table is provided on the final page of this booklet.

Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement Criteria		
Achievement	Achievement with Merit	Achievement with Excellence
Describe properties of particles and thermochemical principles. <input type="checkbox"/>	Explain and apply properties of particles and thermochemical principles. <input type="checkbox"/>	Discuss properties of particles and thermochemical principles. <input type="checkbox"/>
Overall Level of Performance		<input type="checkbox"/>

You are advised to spend 50 minutes answering the questions in this booklet.

Question One: Sulfur, sodium and selenium

Comparisons

a Write the electron configuration using *s,p,d* notation for:

i Se _____

ii S^{2-} _____

b Give an explanation for each of the following:

i The sodium atom is larger than the sodium ion.

ii The sulfur atom is smaller than the sulfide ion.

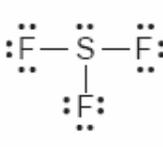
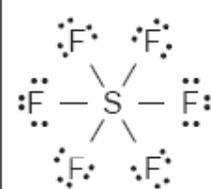
c i Write the equation for the reaction in which the energy change is the first ionisation energy of sulfur.

ii Discuss the factors that cause the first ionisation energy of sulfur to be higher than the first ionisation energies of both sodium and selenium.

Sulfur Fluorides

Sulfur reacts with fluorine to form both SF_4 and SF_6 . These molecules react further to form the positive and negative ions SF_3^+ and SF_5^- .

- d Complete the table below by drawing Lewis diagrams for SF_4 and SF_5^- and determining the shape of SF_3^+ and SF_6 .

	SF_3^+	SF_4	SF_5^-	SF_6
Lewis diagram				
Shape				

- e Discuss the reasons for the difference in the polarity of SF_4 and SF_6 .

Question Two: Some compounds of manganese and zinc (1994 modified)

Manganese is a typical transition metal and forms compounds of different oxidation states.

- a Give the formula and colour of three different *compounds* of manganese, and state the oxidation number of manganese in each case.

Compound formula	Colour	Oxidation state of Mn

- b** Using the result of the calculation in part **a** above, describe, with a reason, whether the heat of formation of ZnS is endothermic or exothermic.

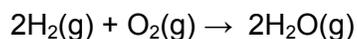
Question Four: Fuel cells

A fuel cell, such as that used on a space-craft, is similar to a battery. An example is the fuel cell that 'burns' hydrogen and oxygen to produce water and energy.

The overall equation for the reaction is



- a** If the water produced is in the gas phase the equation for the reaction is



Use the bond enthalpies on the right to calculate $\Delta_r H^\circ$ for this reaction.

Bond	Bond Enthalpy kJ mol ⁻¹
H-H	436
O=O	498
O-H	460

- b** Write an equation for which the enthalpy change is equal to $\Delta_{\text{vap}} H^\circ (\text{H}_2\text{O})$.

- c** By considering the nature of the reaction in part **b**, describe why it is an endothermic change.

- d Using the information in parts a to c above, calculate the value of $\Delta_{\text{vap}}H^\circ(\text{H}_2\text{O})$.

Question Five: Combustion of ethanol

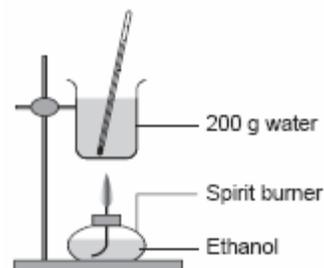
The diagram to the right shows a simple calorimeter.

It can be used to measure the enthalpy of combustion of ethanol, $\text{C}_2\text{H}_5\text{OH}$.

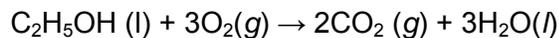
- a If 1.00 g of ethanol is burned in the spirit burner, the temperature of the 200 g of water is found to increase from 22°C to 40°C . Using these results, calculate the experimental value of $\Delta_c H^\circ(\text{C}_2\text{H}_5\text{OH}, \text{l})$.

$$M(\text{C}_2\text{H}_5\text{OH}, \text{l}) = 46 \text{ g mol}^{-1}$$

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



- b The experimental value of $\Delta_c H^\circ(\text{C}_2\text{H}_5\text{OH}, \text{l})$ calculated above, is found to be only about half the 'accepted' value. Use the following data to calculate $\Delta_c H^\circ(\text{C}_2\text{H}_5\text{OH}, \text{l})$.



$$\Delta_f H^\circ(\text{C}_2\text{H}_5\text{OH}, \text{l}) = -277 \text{ kJ mol}^{-1}$$

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

$$\Delta_f H^\circ(\text{CO}_2, \text{g}) = -394 \text{ kJ mol}^{-1}$$

- c Give two reasons why the experimental value for the enthalpy of combustion of ethanol calculated in part a is so much less than the 'accepted' value calculated in part b.

Question Six: Bonding

A chemistry textbook was found to include a table showing the following information.

Substance	Bonds broken	$\Delta_{\text{fus}} H^\circ$ kJ mol ⁻¹	Melting point °C	Boiling point °C
Nitrogen, N ₂	van der Waals	0.38	-210	-198
Heptane, C ₇ H ₁₆	van der Waals	90.6	37	-198
Water, H ₂ O	hydrogen bonds	6	0	100
Sodium chloride, NaCl	ionic	28	801	1487

- a Describe what is meant by the term $\Delta_{\text{fus}} H^\circ$.
- b A knowledge of the nature of the substances in the table would indicate that the row of data for one of the substances is obviously incorrect.
- i Name this substance.
- ii Discuss the nature of bonding in the substances named in the table above, and hence clearly explain why the row of data values can be identified as incorrect.

PERIODIC TABLE OF THE ELEMENTS

																	18											
1	2											13	14	15	16	17	2											
3 Li 6.9	4 Be 9.0	Atomic Number										5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2	1 H 1.0	Atomic Mass									
11 Na 23.0	12 Mg 24.3	3	4	5	6	7	8	9	10	11	12	13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.0	17 Cl 35.5	18 Ar 40.0											
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.6	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 78.9	35 Br 79.9	36 Kr 83.8											
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (98)	44 Ru 101	45 Rh 103	46 Pd 106	47 Ag 108	48 Cd 112	49 In 115	50 Sn 119	51 Sb 122	52 Te 128	53 I 127	54 Xe 131											
55 Cs 133	56 Ba 137	71 Lu 175	72 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 Tl 204	82 Pb 207	83 Bi 209	84 Po 210	85 At 210	86 Rn 222											
87 Fr 223	88 Ra 226	103 Lr 262	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt																				

Lanthanide Series	57 La 139	58 Ce 140	59 Pr 141	60 Nd 144	61 Pm 147	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173
Actinide Series	89 Ac 227	90 Th 232	91 Pa 231	92 U 238	93 Np 237	94 Pu 239	95 Am 241	96 Cm 247	97 Bk 249	98 Cf 251	99 Es 254	100 Fm 257	101 Md 258	102 No 255