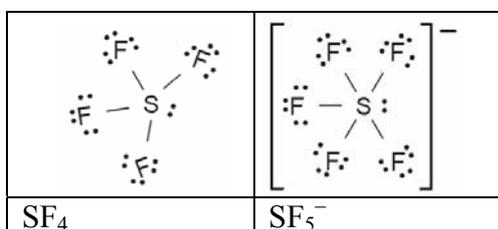


Answers to 3.4 Paper 3 (Based on 2004 exam papers for 90697 and 90699)

Question One

- a i Se: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$ OR $[\text{Ar}] 3d^{10} 4s^2 4p^4$
 ii S^{2-} : $1s^2 2s^2 2p^6 3s^2 3p^6$ OR $[\text{Ar}]$ OR $[\text{Ne}] 3s^2 3p^6$
A = one correct (accept variations such as $3s^2 3p^6$)
- b i When the sodium ion is formed one electron is removed. This results in the loss of a complete energy level. Hence sodium ion has one less energy level so is smaller. (There is a higher effective nuclear charge for Na^+ or Na atom has more shielding. **Not** just less electrons therefore stronger proportional hold.)
 ii Sulfide ion is formed by adding (2) electrons into the valence shell of the sulfur atom. Repulsive forces between the valence electrons increase the size of the electron cloud. Invalid to discuss gain or loss of electrons to increase stability. Neutral to say S^{2-} has lower effective nuclear charge. NOT larger nucleus.
A = Brief explanation for either (i) or (ii) making connection between gain or loss of electrons and relative size, M = Both explanations correct showing clear understanding of relative atomic and ionic size
- c i $\text{S}(\text{g}) \rightarrow \text{S}^+(\text{g}) + \text{e}^-$
A = Correct including at least one inclusion of (g) state
 ii $\text{S} > \text{Na}$; electrons removed from **same energy level** (so same shielding), but **nuclear charge greater** in S so electrons more strongly held.
 $\text{S} > \text{Se}$ because **valence electron is in energy level further from the nucleus** (with more shielding by inner electron shells), so weaker electrostatic attraction and therefore takes less energy to remove an electron.
A = Answer makes basic link eg ionisation energy increases going across a row and decreases down a Group, M = Discussion of both but lacks some detail eg no mention of valence electrons of Na and S being in the same shell or energy level, E = Full and correct discussion

d



**A = Diagrams show correct number of valence electrons OR one diagram correct,
 M = Both diagrams correct
 (May use lines or dots for bonds)**

- e SF_3^+ = Trigonal (or triangular) pyramid (not JUST pyramidal or trigonal)
 SF_6 = Octahedral NOT hexahedral.
A = 2 shapes correct

Question Two

a

Compound	Colour	Oxidation state
MnSO_4	Pink (not colourless)	+2
$\text{MnO}(\text{OH})$	Red	+3
MnO_2	Brown OR black	+4
K_2MnO_4	Green	+6
KMnO_4	Purple	+7

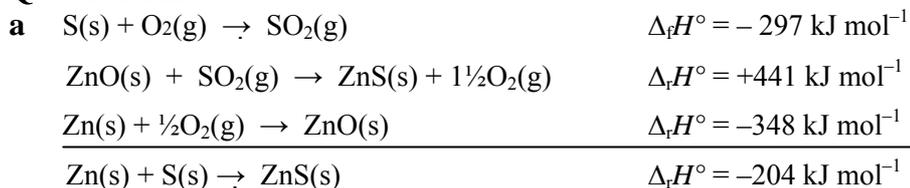
**A = 2 lines correct (accept ions or compounds),
 M = 3 lines correct (must write compounds not ions)**

2

- b Zinc has a full d-subshell (its electron configuration is $[\text{Ar}] 3d^{10} 4s^2$) whereas manganese has a partially-filled d-subshell (electron configuration $[\text{Ar}] 3d^5 4s^2$). Electrons are able to move between the different d orbitals in Mn, absorbing and releasing energy in the visible light region, but this is not possible with Zn. Thus Mn compounds appear coloured while Zn compounds are white.

A = link between partially-filled d-shells and colour, M = full answer

Question Three



A = Correct process with one error,

M = Correct value $\Delta_r H$ with units. (accept kJ or kJ mol⁻¹)

- b Reaction is exothermic since $\Delta_r H$ is negative.

A = Explanation links answer to sign of $\Delta_r H$ calculated

Question Four

a
$$\Delta_r H = \sum E_{\text{bonds broken}} - \sum E_{\text{bonds made}}$$
$$= [(2 \times 436) + 498] - [4 \times 460]$$
$$= +1370 - 1840$$
$$= -470 \text{ kJ mol}^{-1}$$

A = Correct process with one error,

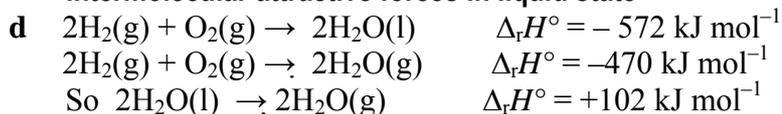
M = Correct value of $\Delta_r H$ with units (accept kJ or kJ mol⁻¹)

- b $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$

A = Correct equation showing states and 1 mol

- c Energy must be absorbed to break the attractions (hydrogen bonds) holding the molecules together in the liquid state.

A = Recognition that bond breaking is endothermic or that energy has to be put in to overcome the intermolecular attractive forces in liquid state



1st equation supplied

Calculated in a

Difference between liquid and gas – an endothermic transformation

Divided by 2 to get 1 mol of H₂O



A = Some recognition of the fact that $\Delta_{\text{vap}} H^\circ$ can be related to the enthalpies of the two reactions in the question, M = Appropriate calculation with one error, E = Correct answer with units of kJ mol⁻¹

Question Five

a

$$\begin{aligned}\Delta T &= 40\text{ }^{\circ}\text{C} - 22\text{ }^{\circ}\text{C} \\ &= 18\text{ }^{\circ}\text{C} \\ E &= ms\Delta T \\ &= 200\text{ g} \times 4.18\text{ J g}^{-1} \times 18\text{ }^{\circ}\text{C}^{-1} \\ &= 15\,048\text{ J} \\ &= 15.048\text{ kJ released}\end{aligned}$$

$$\begin{aligned}n(\text{C}_2\text{H}_5\text{OH}) &= \frac{m}{M} \\ &= \frac{1.00\text{ g}}{46\text{ g mol}^{-1}} \\ &= 0.0217\text{ mol}\end{aligned}$$

$$\begin{aligned}\Delta_c H^{\circ}(\text{C}_2\text{H}_5\text{OH}) &= \frac{E}{n} \\ &= \frac{-15.048\text{ kJ}}{0.0217\text{ mol}} \\ &= -693\text{ kJ mol}^{-1}\end{aligned}$$

A = one step calculated correctly (eg $n(\text{C}_2\text{H}_5\text{OH})$ or energy released),

M = one error in calculation,

E = $\Delta_c H$ calculated correctly including negative sign and correct units of kJ mol^{-1} . Note: penalise use of kJ instead of kJ mol^{-1} in Q4 d and Q5 a only once

b

$$\begin{aligned}\Delta_c H^{\circ} &= \sum \Delta_f H^{\circ}_{\text{products}} - \sum \Delta_f H^{\circ}_{\text{reactants}} \\ &= [(2 \times -394) + (3 \times -286)] - [-277 + 0] \\ &= -1369\text{ kJ mol}^{-1}\end{aligned}$$

A = Correct process for calculation with one error,

M = Answer calculated correctly. (Accept kJ or kJ mol^{-1})

- c**
- Heat is lost to the surroundings/lack of insulation.
 - Some of the ethanol that is burned undergoes incomplete combustion that releases less energy.
 - Experiment not carried out under standard conditions.

A = One correct reason given, M = A physical and a chemical reason given

Question Six

- a** It is the enthalpy change when one mole of a solid is melted to its liquid state under standard conditions.

A = Correct definition

- b i** Heptane

ii Heptane is a small non-polar molecule so the only intermolecular forces are weak. This means heptane will have low values for melting point, boiling point and heats of fusion as all are measures of the strength of intermolecular forces.

Sodium chloride is an ionic solid with strong ionic bonds between all ions in the 3-D network.

Water has hydrogen bonds between its molecules and this type of intermolecular attraction is stronger than the instantaneous dipole-dipole attractions that exist between the non-polar heptane or nitrogen molecules.

This type of attraction is greater for heptane than nitrogen because of its larger electron cloud/molar mass.

Specific comparisons or justifications that can be made include:

- Boiling point of heptane should be higher than its melting point.
- Melting point for heptane is wrong as it is a liquid at room temperature.

- The high heat of fusion for heptane is inconsistent with its low boiling point.
- The boiling point of heptane should be higher than that for nitrogen.
- The heat of fusion for heptane should be lower than the value for either NaCl or H₂O.
- The melting point for heptane should be lower than that for water.
- Heptane has a boiling point much lower than water so also should have a heat of fusion that is much lower – contradictory.

A = Incorrect line of data identified with at least one valid justification,

M = Incorrect line of data identified with justifications recognising the link between the type of attractive forces and the physical property,

E = Incorrect line of data identified with a comprehensive justification clearly linking the appropriate comparison to the difference in the nature of the attractions involved

Judgement Statement

Achievement: 11 questions answered correctly
A minimum of $11 \times A$

Merit: 13 questions answered correctly with 7 at Merit level.
A minimum of $6 \times A + 7 \times M$

Excellence: 15 questions answered correctly with 9 at Merit level and 3 at Excellence level.
A minimum of $3 \times A + 9 \times M + 3 \times E$