Answers to 3.4 Paper 2

Question One

a double bond at β–carbon, 2 lone pairs on α–oxygen,
2 lone pairs on β–oxygen, 1 lone pair on N
A = 2 or 3 correct, M = 4 correct

b 4 electron clouds (regions of negative charge) / 2 lone pairs, hence tetrahedral angle
3 electron clouds (regions of negative charge)**,** hence triangular angle
A = 1 correct statement, M = 2 correct statements

Question Two

a **i** $1s^2 2s^2 sp^6 3s^1$ **or** $[Ne]3s^1$ A

ii Ne to Na decrease in IE: the electron removed is further from nucleus in Na than Ne so less energy is required to remove it. Na to Mg increase in IE: valence electron is in the same shell, but the nuclear charge is greater for Mg so more energy is required to remove it.
A = both trends correct, M = plus one correct explanation for trend, E = both correct explanations

iii Energy is required to overcome the force of attraction between electron and nucleus, this is endothermic. M

b Electronegativity is the ability of atom to attract electrons in a bond. A

c Ne does not form bonds/compounds. A

d In bonding, the electrons in fluorine are less shielded from nuclear charge (closer to the nucleus) so are attracted more. Hence, greater electronegativity.
A = idea of distance from the nucleus, M = complete explanation

e **i** solid A

ii $MgAt_2$ A

iii Astatine has an extra shell of electrons (energy level) and these electrons are further from the nucleus making the atom larger
A = correct statement, M = plus correct effect

Question Three

a **i** Cr A

ii Zn (Sc) A

iii Mn (Co) A

b **i** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ / $[Ar]\ 3d^{10}$ A

ii Cu^+ has filled d orbitals (d^{10}), while Cu^{2+} has partially-filled d orbitals (d^9). The unpaired d electrons absorb light (energy in the visible region of the electromagnetic spectrum) as they move between orbitals. This makes the compound coloured.
A = mention of different electronic structure, M = plus idea of absorbing light,
E = complete explanation of how light is absorbed

Question Four

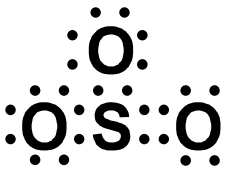
a

SO_2

or

bent or
v shaped

SO_3



trigonal planar or
triangular planar

A = one correct, M = both correct

2

b SO_3 : because the polar bonds are arranged symmetrically around the central atom and the dipoles cancel.

A = correct choice, M = correct explanation

c Size of electron cloud : If polarity was the main factor SO_2 would have the higher boiling point because it is the more polar molecule. However, SO_3 has the larger electron cloud and the higher boiling point even though it is non-polar.

A = correct answer, M = one factor correctly mentioned, E = both factors correctly stated

Question Five

a $\Delta_r H = \sum E_{\text{bonds formed}} + \sum E_{\text{bonds broken}}$ (N.B.bonds formed are exothermic)

$90 = -$ bond enthalpy (NO) + ½ × 945 + ½ × 498

bond enthalpy (NO) = 631.5 kJ mol^{-1}

A = correct equation, M = correct calculation with minor error, E = correct answer with units

b 2 mol NO = 60 g

60 g releases 114.1 kJ

100 g releases $\frac{114.1}{60}$ × 100 kJ = 190.1 k

A = correct method with minor error, M = correct answer with units

Question Six

a The boiling point decreases from HF to HCl and then increases from HCl to HI. The boiling point of HF is high because of the hydrogen bonds between the molecules. The stronger the bonds, the more energy required to break them. From HCl to HI there are no hydrogen bonds, but the size of the electron cloud increases (the size of the molecules increases) so the Van der Waals forces (intermolecular forces) increase so the boiling point increases.

A = correct trend for both parts, M =plus correct explanation of one part of trend, E = correct explanation of both parts of trend

b The bond enthalpy of HF is higher than the other hydrogen halides. The stronger the bond, the harder it is to ionise and the weaker the acid (less tendency to donate hydrogen ions).

A = mention of bond strengths, M = plus link to ability to donate protons

c Molecules with double bonds do not pack together as well as molecules with single bonds. The energy required to separate the molecules is less. Hence, the melting point of cis-octadec-9-enoic acid is lower than the saturated octadecanoic acid of similar molar mass

A = mention of bond strengths, M = plus idea of packing of molecules with double bonds

d Calculate the standard enthalpy change for the formation of $C_3H_5N_3O_9$ given

$4C_3H_5N_3O_9(l) + 11O_2(g) \rightarrow 10H_2O(g) + 12CO_2(g) + 12NO_2(g)$ $\quad \Delta_r H° = -6160$ kJ mol^{-1}

. $\quad ½N_2(g) + O_2(g) \rightarrow NO_2(g)$ $\quad \Delta_f H° = 34$ kJ mol^{-1}

$\quad C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta_f H° = -394$ kJ mol^{-1}

$\quad H_2(g) + ½O_2(g) \rightarrow H_2O(g)$ $\quad \Delta_f H° = -242$ kJ mol^{-1}

$\Delta_r H = \sum \Delta_f H^\circ_{(\text{products})} - \sum \Delta_f H^\circ_{(\text{reactants})}$

$-6160 \text{ kJ mol}^{-1} = 10(\Delta_f H°(H_2O) + 12(\Delta_f H°(CO_2) + 12(\Delta_f H°(NO_2) - 4(\Delta_f H°(C_3H_5N_3O_9) - 11(0)$

$4(\Delta_f H°(C_3H_5N_3O_9) = 6160 + 408 - 2420 - 4728$

$= -580$ kJ

$\Delta_f H°(C_3H_5N_3O_9) = \frac{-580 \text{ kJ}}{4 \text{ mol}}$

$= -145 \text{ kJ mol}^{-1}$

A = correct equation, M = correct calculation with minor error, E = correct answer with units

Judgement Statement

Achievement**:** 13 questions answered correctly.
A minimum of 13 × A

Merit**:** 16 questions answered correctly with 9 at Merit level.
A minimum of 7 × A + 9 × M

Excellence: 18 questions answered correctly with 11 at Merit level and 3 at Excellence level ((at least one from each category – structure, thermochemistry)
A minimum of 4 × A + 11 × M + 3 × E