Answers to 3.4 Paper 1

Question One

a i Decreases A

ii Electrons in the bond are unevenly shared **or** bond with $\delta+$ and $\delta-$ ends.
Chlorine has a stronger attraction for the bonding electrons.
A = correct statement, M = correct explanation

b i Al^{3+} is smaller than Mg^{2+} and bigger than B^{3+}, while P^{3-} is bigger than N^{3-}. A = both correct

ii B^{3+} has no electrons in its second shell, it has only the 2 electrons in shell 1. N^{3-} on the other hand has gained 3 electrons and has a full second shell which is further from the nucleus making it larger. These extra electrons repel one another and expand this shell also.
A = one point, M = both points

iii The nuclear charge is smaller in H^- **or** the nuclear charge is larger in Li^+, so the electrons are pulled closer to the nucleus in Li^+.
A = idea of different nuclear charges, M = complete explanation

c i 6 A

ii TeH_2 (accept H_2Te) A

d i less than 1000 kJ mol^{-1} A

ii The energy level or shell containing the valence electrons is further from the nucleus and so less energy is required to remove an electron from the pull of the nucleus.
A = idea of distance from the nucleus, M = complete explanation

Question Two

a i electron configuration OR kernel/core of argon, Ar ($1s^2 2s^2 2p^6 3s^2 3p^6$)
A = first part, M = includes configuration

ii Fe^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ **or** [Ar]$3d^6$ A

b i $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$ A

ii $Ca(g) \rightarrow Ca^+(g) + e^-$ A

Question Three

a Gas A

b Hexane will be on top because it has a lower density.
A = correct liquid, M = correct explanation

c The boiling points of the alkanes increases, because as the size of the electron cloud (number of electrons) in the molecules increases, the size of the dipoles (instantaneous/temporary/induced) between the molecules is greater (occurs more often).
A = correct trend, M = correct explanation

d Pent-1-ene has instantaneous/temporary/induced dipoles between the molecules which are weaker than the H- bonds/ dipole-dipole attractions between the butan-1-ol molecules.
A = correct forces for one of the materials, M = correct forces for both or one force and compares strength, E = correct forces for both and comparison of strengths

e butane : $\dfrac{2877 \text{ kJ mol}^{-1}}{58.1 \text{ g mol}^{-1}} = 49.52 \text{ kJ g}^{-1}$

octane : $\dfrac{5470 \text{ kJ mol}^{-1}}{114.2 \text{ g mol}^{-1}} = 47.89 \text{ kJ g}^{-1}$

Hence, butane generates the more energy per gram when burnt in oxygen.
A = correct answer, M = correct calculations with units

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

$\Delta H = -84 \text{ kJ mol}^{-1} - (-52 \text{ kJ mol}^{-1} + 0)$

$= -32 \text{ kJ mol}^{-1}$

A = correct formula, M = correct calculation with units

Question Four

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

$247 = -(414 + 3 \times 436 + [C \equiv N]) + 4 \times 414 + 3 \times 391$

$= -(3 \times 436 + [C \equiv N]) + 3 \times 414 + 3 \times 391$

$C \equiv N = 860 \text{ kJ mol}^{-1}$

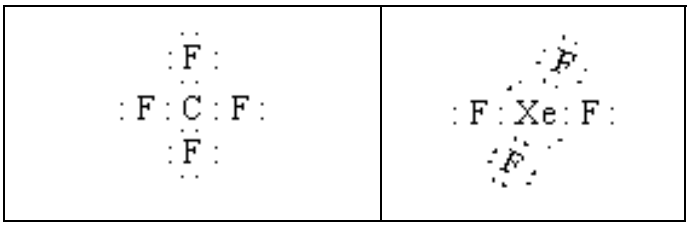
A = correct equation, M = correct calculation with minor error, E = correct answer with units

b It increases the rate of reaction by providing an alternative reaction pathway, eg. lowers the energy of activation E_A or orientates the reactants.

A = one point, M = both points

Question Five

a



A = one correct electron arrangement, M = both correct electron arrangements

b CF_4: 4 electron clouds; tetrahedral arrangement; non-polar molecule because the bond dipoles are balanced due to its symmetrical shape.

XF_4: 6 electron clouds (4 bonding and 2 non-bonding); square planar; non-polar molecule because the bond dipoles are balanced due to its symmetrical shape.

A = correct shapes, M = correct polarities, E = correct justifications

Question Six

$C(s) + \frac{1}{2}O_2(g) + N_2(g) + 2H_2(g) \rightarrow CO(NH_2)_2(s)$

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	$2 \times (\Delta_f H^\circ = -46 \text{ kJ mol}^{-1}) = -92 \text{ kJ mol}^{-1}$
$2NH_3(g) + CO_2(g) \rightarrow CO(NH_2)_2(s) + H_2O(g)$	$\Delta_r H^\circ = +5 \text{ kJ mol}^{-1}$
$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$	$\Delta_r H^\circ = -41 \text{ kJ mol}^{-1}$
$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$	$\Delta_f H^\circ = -111 \text{ kJ mol}^{-1}$

Add to give $\Delta_f H^\circ = -239 \text{ kJ mol}^{-1}$

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 8 at Merit level
A minimum of 8 × A + 8 × M

Excellence: 18 questions answered correctly with 10 at Merit level and 2 at Excellence level (one from each category – structure, thermochemistry)
A minimum of 6 × A + 10 × M + 2 × E