1.

(a) $Cr_2O_7^{2-}{}_{(aq)} + 6e^- + 14H^+{}_{(aq)} \rightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$ **(1 point)**

Reduction **(1 point)**

(b) $6Fe^{2+}{}_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} + 6e^- + 14H^+{}_{(aq)} \rightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)} + 6Fe^{3+}{}_{(aq)}$ **(2 points)**

(c) Moles of dichromate(VI) = (42.5/1000)(0.0411) = 0.00174675 moles **(1 point)**

Moles of $Fe^{2+}{}_{(aq)}$ = (6)(0.00174675) = 0.0104805 moles

Moles of Fe = 0.0104805 moles

Mass of Fe = (0.0104805)(55.85) = 0.585 g **(1 point)**

% of iron in wire = (0.585)/(0.625)*100 = 93.6 % **(1 point)**

(d)

(i) No effect. The acid is only required in order to dissolve the iron wire, and has no effect on any of the calculations of the moles of iron or dichromate (VI). **(1 point)**

(ii) % too large. Too large a volume of dichromate(VI) causes the moles of dichromate(VI) to be too large, the moles of $Fe^{2+}{}_{(aq)}$ and Fe to be too large, the mass of Fe to be too large and the % to be too large. **(1 point)**

(e) |(23.4 - 45.2)/(45.2)|*100 = 48.2 % **(1 point)**

2.

(a) Negative **(1 point)**

(b) The cold water (or alternatively 'the universe' or anything outside of the reaction/system). **(1 point)**

(c) From the system to the surroundings (i.e., from the fission reaction to the cold water) **(1 point)**

(d) Thermal equilibrium **(1 point)**

(e)

(i) $C_xH_{y(l)} + (x + y/4)\ O_{2(g)} \rightarrow x\ CO_{2(g)} + y/2\ H_2O_{(g)}$ **(2 points. 1 for the equation, 1 for balancing)**

(ii) Positive. The number of moles of gas increases, which increases the disorder, making $\Delta S°$ positive. **(2 points)**

(iii) The 100.0 g sample. Since $q = m\ c\ \Delta T$, and q and c are the same in each experiment, ΔT is inversely proportional to m. **(2 points)**

3.

(a) Since a buffer solution is formed in the flask, halfway to the equivalence point,

$pH = pKa = 4.89 = -\log Ka$

$Ka = 10^{-4.89}$

$Ka = 1.3 \times 10^{-5}$ **(2 points)**

(b) $pH = 2.64 = -\log[H_3O^+]$

$[H_3O^+] = 2.3 \times 10^{-3}$

$Ka = \frac{[H_3O^+][A^-]}{[HA]} = \frac{[H_3O^+]^2}{[HA]} = \frac{[2.3 \times 10^{-3}]^2}{[HA]} = 1.3 \times 10^{-5}$

$[HA] = 0.40$ M **(2 points)**

(c) $HA + NaOH \rightarrow NaA + H_2O$

Moles of HA = (20.00/1000)(0.40) = 0.0080 moles

Moles of NaOH = 0.0080 moles

Molarity of NaOH = 0.0080/(30.00/1000) = 0.27 M **(1 point)**

(d) $Kw = 1 \times 10^{-14} = (Ka)(Kb) = (1.3 \times 10^{-5})(Kb)$

$Kb = 7.69 \times 10^{-10}$ **(1 point)**

Moles of A^- at equivalence point = 0.00806 moles, in a total volume of 50.00 mL

$[A^-] = 0.0080/(50.00/1000) = 0.16$ M **(1 point)**

$A^- + H_2O \rightleftharpoons HA + OH^-$

$Kb = \frac{[HA][OH^-]}{[A^-]} = \frac{[OH^-]^2}{[A^-]} = \frac{[OH^-]^2}{0.16} = 7.7 \times 10^{-10}$

$[OH^-] = 1.1 \times 10^{-5}$

$pOH = -\log(1.1 \times 10^{-5}) = 4.95$

$pH = 14 - 4.95 = 9.0$ **(2 points)**

(e) OH^- **(1 point)**

4.

(a) Q = $\frac{[Al^{3+}]^2}{[Fe^{2+}]^3} = \frac{[1.0]^2}{[1.0]^3} = 1$ **(1 point)**

(b) It will increase **(1 point)**

(c) Q = $\frac{[1.4]^2}{[0.4]^3}$ = 31, which is closer to K than the original value of Q, so the cell is closer to equilibrium. Since the voltage at equilibrium = 0 V, then the cell is closer to a voltage of 0 V, and therefore the voltage will be lower than E°. **(2 points)**

5.

(a) Rate = k $[NO_2]^2$ **(1 point)**

(b) It quadruples **(1 point)**

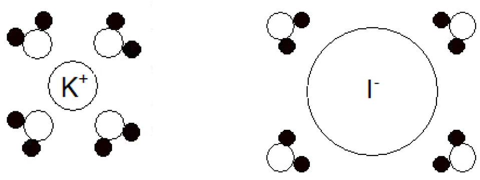
(c) With increasing temperature, the particles in the reaction gain kinetic energy. With the increased kinetic energy more collisions occur, and a greater proportion of the particles have sufficient energy to overcome the activation energy. As such, more of the collisions are successful, i.e., lead to a reaction. **(2 points)**

6.

(a) The polar water molecules are attracted to the positive and negative ions of KI, where ion to dipole interactions take place, causing the ions to become hydrated and the KI to dissolve **(1 point)**

I_2 is a non-polar molecule, so the polar water molecules are attracted to them extremely weakly, and no such hydration takes place **(1 point)**

(b) Ion to dipole attractions between the water molecules and each ion **(1 point)**



(1 point)

7.

(a) $Na_2CO_{3(s)} \rightarrow Na_2O_{(s)} + CO_{2(g)}$ **(1 point)**

(b) Positive **(1 point)**

(c) 1.15. Kp = pp CO_2. **(2 points)**