SEPTEMBER 2009
MHS TRIAL NOVEMBER EXAM
SOLUTIONS

Penalties : the usual ones!
* max[m] 1 mark off if incorrect numbers of significant figures are given
* max[m] 1 mark off if symbols of state are omitted
* 1 mark off each time a unit is omitted from answer that requires a unit

SECTION A $\Sigma = 20$

1. A	2. A	3. D	4. B	5. C	6. D	7. B	8. B	9. C	10. A
11. C	12. B	13. B	14. D	15. C	16. C	17. B	18. D	19. D	20. D

SECTION B $\Sigma = 57$ marks * = one mark

1. (1 + 2 + 1 + 3 = 7)

a) $K = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$ *

b) $CF = (0.40)^2/0.30 \times 0.40^3 = 8.3\ M^{-2}$.
The concentration fraction of $8.3\ M^{-2}$ is higher than the equilibrium constant of $0.50\ M^{-2}$. *
The system is not in equilibrium* and would have to proceed to the left to approach equilibrium.

c) i As the temperature increases the yield of ammonia decreases therefore the reaction must be exothermic. *
or as the temperature decreases the yield of ammonia increases therefore the reaction must be exothermic.

c) ii If you increase the pressure, according to Le Chatelier's principle the system will shift so as to partially oppose this change.* The reaction will shift to try and lower the pressure* and move to the side with fewer particles, in this reaction the products side and the yield of ammonia increases.*

2 (2 + 2 = 4)

i The calibration factor for a calorimeter is the amount of energy required to change the temperature of the calorimeter and its contents by 1 ºC.
The time, t, used in the calculations must be in seconds
Energy = $V \times I \times t = 5.63 \times 4.52 \times 10.00 \times 60 = 1.53 \times 10^4$ J *
$\Delta T = 21.866 - 21.362 = 0.504$ ºC
$CF = E / \Delta T = 1.53 \times 10^4 / 0.504 = 3.04 \times 10^4$ J ºC^{-1} *

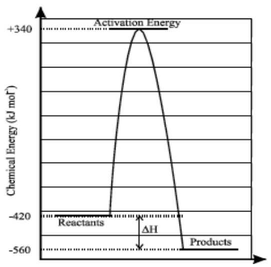
ii. For the combustion of the brown coal.
$\Delta T = 23.819 - 21.866 = 1.953$ ºC
$E = CF \times \Delta T = 3.04 \times 10^4 \times 1.953 = 5.94 \times 10^4$ J = 59.4 kJ *
This energy is released by 2.036 g of coal therefore from 1.00 kg (1000 g)
$E = (59.4 / 2.036) \times 1000 = 2.92 \times 10^4$ kJ kg^{-1} *

3 (1 + 3 = 4)

a) $CH_3CH_2COOH(aq) + H_2O(l) \rightleftharpoons CH_3CH_2COO^-(aq) + H_3O^+(aq)$ *

b) $K_a = [CH_3CH_2COO^-][H_3O^+] / [CH_3CH_2COOH] = 1.3 \times 10^{-5}$ M
At eqm, $[CH_3CH_2COO^-] = [H_3O^+]$, *
since propanoic acid is a weak acid, very little of it is hydrolysed so we assume that the concentration of propanoic acid is still 0.150 M (the weak acid assumption)
$\therefore [H_3O^+]^2 = K_a \times [CH_3CH_2COOH] = 1.3 \times 10^{-5} \times 0.0150$ *
$\therefore [H_3O^+] = \sqrt{(1.3 \times 10^{-5} \times 0.0150)}$ M
$\therefore pH = -\log_{10}(\sqrt{(1.3 \times 10^{-5} \times 0.0150)}) = 3.3$ *

4a) i



(3 + 1 + 1) + (1 + 1) + (2 + 1 + 2) = 12
The energies for the reactants and products must be shown as - 420 and -560 kJ mol^{-1} respectively.*
The activation energy position must be shown
$-560 + 900 = +340$ kJ mol^{-1}.*
The ΔH must be shown as the energy difference between the reactants and products.*

4a)ii. The enthalpy change is the difference between the chemical potential energy of the products and reactants.
ΔH = E(products) – E(reactants) = $-560 - (-420) = -140$ kJ mol^{-1}. *

iii. The activation energy for the forward reaction is,
Ea(forward) = $340 - (-420) = 760$ kJ mol^{-1}. *

b) i $2HCHO(g) + O_2(g) \rightarrow 2HCOOH(g)$ *

ii $\Delta H = -464 - (-194) = -270$ kJ mol^{-1} *

c) i. Lowering the temperature lowers the average kinetic energy of the particles *, therefore less particles will have sufficient energy for a fruitful collision thereby lowering the rate of reaction.*
In addition the lower average kinetic energy will result in the particles travelling more slowly therefore there will also be a less likelihood of a collision occurring between the particles also contributing to a lower rate of reaction.

ii. The zinc powder has a higher surface area (*/2) therefore there will be more sites available for a fruitful reaction to occur (*/2), increasing the rate of reaction.

iii. A catalyst provides an alternative reaction pathway with a lower activation energy (*), therefore at a given temperature in the presence of a catalyst, more particles will have sufficient energy for a fruitful collision to occur. (*)

5 (2 + (1 + 3) + (1 + 1) + (1 + 1) = 10)

a) - Bioethanol can be produced by fermentation of crops, eg corn or sugar cane waste. (*/2) The fermentation mixture must be distilled to separate the ethanol. *
- Biodiesel is produced by reacting fatty acids or vegetable oils with methanol (or alkyl group) to produce methyl esters or alkyl ester of the fatty acid.*

b) i $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

ii $M(C_2H_5OH) = 2 \times 12.0 + 6 \times 1.0 + 16.0 = 46.0$ g mol^{-1}
From Data book the molar enthalpy of combustion for ethanol is -1364 kJ mol^{-1}
Therefore 1 mol of ethanol will release 1364 kJ of energy when burnt.
Therefore 1.00 g of ethanol releases 1364 / 46.0 = 29.65 kJ *
$M(C_8H_{18}) = 8 \times 12.0 + 18 \times 1.0 = 114.0$ g mol^{-1}
From Data book the molar enthalpy of combustion for octane is -5464 kJ mol^{-1}
Therefore 1 mol of octane will release 5464 kJ of energy when burnt.
Therefore 1.00 g of octane releases 5464 / 114.0 = 47.93 kJ *
Octane releases about 60% more energy per gram than ethanol * (47.93/29.65 x 100/1)

c)i Possible answers could include: *
- The blended fuel contains bioethanol which is a renewable resource.
- The use of bioethanol will reduce the demand on the limited fossil fuel reserves of crude oil.
- The bioethanol can be produced locally and therefore reduces imports of crude oil.
- Growing the feedstock for bioethanol production will mean that the carbon dioxide emitted by the ethanol will be removed from the atmosphere.

ii. Possible answers could include: *
- The use of food crops to produce bioethanol has increased the price of many staple foods.
- Biofuel production is currently receiving large government subsidies.
- Land for growing biofuels is resulting in deforestation.
- Land being used to grow biofuels is lowering the amount of land available for growing food crops.
- Water resources are being taken away from growing food crops to produce biofuel crops.

d)i Methane is produced by the decomposition of biological wastes in landfills or at sewage plants. (*/2) These sources of methane are regarded as biofuels as they are immediate or renewable as they have not taken millions of years to form or part of fossil fuels. (*/2)

ii Methane would be released naturally from landfills and would contribute to greenhouse gases anyway. (*/2) By burning this source of methane and not natural gas we do not increase the net greenhouse gas emissions. (*/2)

6 (1 + 1 + 1 + 1) + (1 + 1 + 1) + (1 + 2)

a) $Ni^{2+}(aq)/Ni(s)$ standard half cell coupled with any non-gas standard half cell with $E^o \geq +0.77$ V
for example: oxidation occurs at the $Ni^{2+}(aq)/Ni(s)$ and electrons produced at Ni electrode as $Ni(s) \rightarrow Ni^{2+}(aq) + 2e$
The other half cell can be one of Au^+/Au, Ag^+/Ag or Fe^{3+}/Fe^{2+} (other possibilities exist)
Cell must show the following:
- solutions (including anion) and their concentrations (1 M) *
- solids used as the electrodes *
- direction of e- flow in external circuit (from Ni(s) electrode) *
- polarity of the half cells *

b) * Cathode (Appropriate reduction reaction)
* Anode $Ni(s) \rightarrow Ni^{2+}(aq) + 2e$
* Overall (also receive 1 mark for consequential answer provided that the half equations contain electrons.)
half equations: ½ mark only if all species are correct but the half equation is unbalanced.

c) i. ammonium nitrate, sodium nitrate, potassium nitrate, etc. [Don't accept acids, hydroxides, halides, etc.]*

ii. Assuming KNO_3: the formation of extra +ve ions (Ni^{2+}) at the anode is counterbalanced by the nitrate ions flowing out of the salt bridge into the anode solution *; the potassium ions flow from the salt bridge into the cathode electrolyte replacing the +ve ions (Ag^+) that are reduced * (or equivalent, depending on choice of cathode half cell).

7 (1 + 1 + 1) + 1 + 1 = 5)

a) oxidation: $C_4H_4O_6^{2-}(aq) + 2H_2O(l) \rightarrow 2HCOO^-(aq) + 2CO_2(g) + 6H^+(aq) + 6e^-$ *
reduction: $(H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)) \times 3$ *
overall: $C_4H_4O_6^{2-}(aq) + 3H_2O_2(aq) \rightarrow 2HCOO^-(aq) + 2CO_2(g) + 4H_2O(l)$ *
(also receive 1 mark for consequential answer provided that the half equations contain electrons.
half equations: ½ mark only if all species are correct but the half equation is unbalanced.
- 1 mark if the oxidation and reduction reactions are around the wrong way.)

b) $2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$ *

c) Rate of disproportionation is very low when hydrogen peroxide is kept in the dark (*/2) - light supplies the activation energy for the decomposition. (*/2)

8 (4 x ½ = 2)
Secondary cells (*eg* Nicad cell, lead/acid accumulator) (*/2) have a finite amount of reactants which, when used, have to be regenerated (*ie* by recharging the cell) (*/2) - hence secondary cells store a limited amount of electrical energy as chemical energy.
Fuel cells (*eg* hydrogen/oxygen or methane/oxygen fuel cell) (*/2) can convert chemical energy continuously into electrical energy provided they are continually supplied with the fuel and the oxidant. (*/2)

9 (1 + 2 = 3)

a) $C(s) + 2O^{2-}(l) \rightarrow CO_2(g) + 4e^-$ * (care with states!)

b) $Al^{3+}(aq)$ ions are a weaker oxidant than water and $Cl^-(aq)$ ions are a weaker reductant that water.* Thus, less energy required to reduce the water than the Al^{3+} ions and to oxidise the water than the Cl^- ions. Hence, if an aqueous solution were used, the water would be electrolysed preferentially and no aluminium would be produced. *

End of Answer