4solutions2011-Version 2

SEPTEMBER 2011
MHS - UNIT 4 TRIAL 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

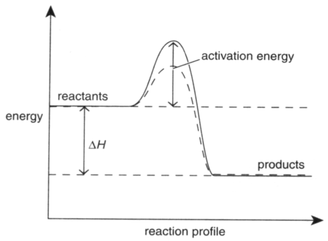
SECTION A $\Sigma = 20$

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

SECTION B $\Sigma = 60$ marks * = one mark

1a The strong triple covalent bond between nitrogen N_2 atoms, requires a large amount of energy to break the bonds and free the nitrogen atoms. *

b



** for profile
* for reduced activation energy – dotted line

ci K_a $= [NH_3]\,[H_3O^+] / [NH_4^+]$ *

cii $[H_3O^+] = [NH_3]$
$[NH_4^+] = 0.10$ M
K_a $= 5.6 \times 10^{-10} = [H_3O^+]^2 / 0.10$
$[H_3O^+]^2 = 5.6 \times 10^{-11}$
$[H_3O^+] = 7.48 \times 10^{-6}$ *
pH $= -\log[H_3O^+] = -\log(7.48 \times 10^{-6})$
$= 5.1$*

(1 + (2 + 1) + (1 + 2) = 7 marks)

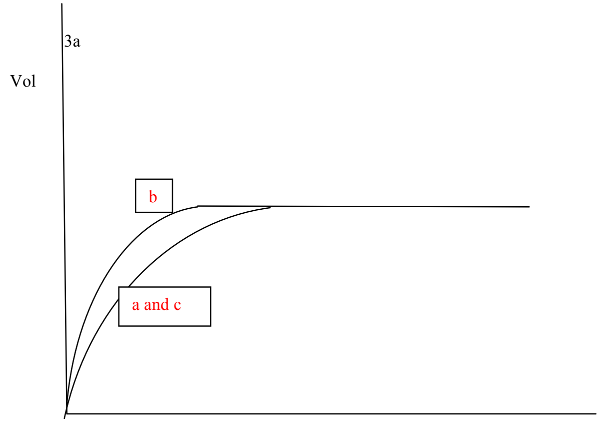
2 a

Change from the conditions in the reference system	Effect on yield of HCN(g) compared with reference system
1. The equilibrium mixture is maintained at 800 °C for twice the period of time before cooling.	**no change ***
2. The same initial amount of ammonia but twice the original amount of carbon monoxide is used.	**Increase ***
3. The reaction temperature is 1100 °C instead of 800 °C.	**Increase ***
4. Palladium, a solid at 800 °C, is present in the reaction vessel. Palladium adsorbs hydrogen.	**Increase ***
5. Replacing the alumina with a more effective solid catalyst such as a transition metal oxide.	**no change ***

b Since palladium adsorbs hydrogen gas, the concentration of hydrogen will be lower than in the reference equilibrium system. Thus the forward reaction will be favoured in order to replenish the hydrogen. This is accompanied by the formation of additional hydrogen cyanide so the yield of hydrogen cyanide will be greater. *

((1 x 5) + 1 = 6 marks)

3a



b Increasing the temperature increases the rate at which hydrogen is produced. The time taken to reach the maximum volume of hydrogen is decreased. *

c As temperature increases, more particles will have higher kinetic energies, and therefore the number of particles with KE greater than the activation energy increases leading to a large increase in the proportion of particles with enough E to react.* This factor has a greater impact on rate than an increase in the number of successful collisions at higher temperature. *
(if students just say it increases the number of successful collisions they do not get full marks)

((1 + 0.5+ 0.5) + 1 + 2 = 5 marks)

4a $K_a = [H^+]\,[OBr^-] / [HOBr]$ $[H^+] = [OBr^-]$
$K_a = [H^+]^2 / [HOBr]$
$2.4 \times 10^{-9} = [H^+]^2 \times 0.15$
$[H^+]^2 = 2.4 \times 10^{-9} \times 0.15$
$[H^+] = [OBr^-] = \sqrt{(2.4 \times 10^{-9} \times 0.15)} = 1.9 \times 10^{-5}$ M *
% ionisation = $[OBr^-]/[HOBr] \times 100/1$
% ionisation = $1.9 \times 10^{-5} \times 100 / 0.15 = 0.013\%$ *

b)

Beaker number	$[H_3O^+]$	$[OH^-]$	K_a	% ionisation
1	**decrease**	**increase**	**No change**	**increase**
2	**decrease**	**increase**	**No change**	**increase**
3	**decrease**	**increase**	**No change**	**increase**

(2 + (12 x .5) = 8 marks)

5a $E = SHC \times m(H_2O) \times \Delta T$
$= 4.18 \times 200 \times (85.6 – 22.7)$ *
$= 52{,}584$ J = 52.6 kJ * (answer to 3 sig figs)

b $m(C_3H_8) = (125.62 – 122.89) = 2.73$ g
$n(C_3H_7OH) = 2.73 / 60.0 = 0.0455$ *
Enthalpy of combustion = $52.8 / 0.0455 = 1.16 \times 10^3$ kJ mol^{-1} *

c % of chemical energy into water = (calculated enthalpy / theoretical enthalpy) x 100 / 1
= (1160 / 2016) x 100 / 1 = 57.5 % *

d - less heat loss to surroundings due to the insulated container*
- more complete combustion of 1-propanol in pure oxygen*
- we have assumed that all heat has gone into the water only*
(any 2 of these 3)

(2 + 2 + 1 + 2 = 7 marks)

6a Equation: $HCl + NaOH \rightarrow NaCl + H_2O$ therefore 1: 1 mole reacts
NaOH is in excess *– n = c x V => .20 x .600 =0.12 mole
HCl n = c x V => .20 x .400 =0.080 mole
Same amount as in the question therefore energy released
= 4.6 kJ * (2 sig figs)

b $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ *
0.080 mole => 4.56 kJ therefore
1 mole => 4.56/0.080 = 57 kJ (*/2 – must show calculation)
$\Delta H = 57\ kJ\ mol^{-1}$ */2

c E = SHC x $m(H_2O)$ x ΔT
ΔT = E/ SHC x $m(H_2O)$ *
= 4560/4.18 x 1000
= 1.09 °C * (3 sig figs)

(2 + 2 + 2 = 6 marks)

7a the separator prevents direct contact between the oxidant and the reductant but allows the ions of the electrolyte to pass through. *

b i. Zn ii. Zn iii. Mn_2O_3 iv. K^+ (*/2 for each one = 2 marks)

c Half equations must be matched correctly with the anode and cathode labels for full credit.
anode: $Zn(s) + 2OH^-(aq) \rightarrow Zn(OH)_2(s) + 2e^-$ *
cathode: $2MnO_2(s) + H_2O(l) + 2e^- \rightarrow Mn_2O_3(s) + 2OH^-(aq)$ *

(2 + 2 + 2 = 6 marks)

8a glucose/oxygen fuel cell: must show
separately labeled anode */2 and cathode chambers, */2
oxygen entering cathode chamber */2, glucose entering anode chamber */2
2 x porous graphite electrodes separating chambers and products*

b $C_6H_{12}O_6(aq) + 6H_2O(l) \rightarrow 6CO_2(g) + 24H^+(aq) + 24e^-$ *

c hydrochloric acid, ammonium chloride solution - any reasonable source of hydrogen ions *

d 12 ÷ 1.26 = 9.5 ∴ **10 cells** required (*must round up)* *

e glucose - renewable, no NO_x produced, direct conversion lessens energy losses, etc. *

(3 + 1 + 1 + 1 +1 = 7 marks)

9 Changes in $[H^+]$ causes pH changes. The overall reaction for discharging lead/acid accumulator is:
$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$
Thus, when current is being delivered, the concentration of H^+ ions decreases, so the pH increases. *
The recharging process involves the reverse reaction, *ie*
$$2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq)$$
so that the sulfuric acid is regenerated and the pH decreases. *
* for reasonable attempt at full or half equations.

(3 marks)

10a combustion reaction involving methane is
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$ */2
Solid oxide methane / oxygen fuel cell reactions
anode $4O^{2-}(s) + CH_4(g) \rightarrow CO_2(g) + 2H_2O(g) + 8e^-$
cathode $O_2(g) + 4e^- \rightarrow 2O^{2-}(s)$ x 2
overall $4O^{2-}(s) + CH_4(g) + 2O_2(g) + 8e^- \rightarrow CO_2(g) + 2H_2O(g) + 8e^- + 4O^{2-}(s)$ *
After cancelling electrons and ions on both sides of the equation
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$ */2
Therefore the equations are the same

b Advantage: Direct production of electrical current, higher efficiency of transformation etc *
Disadvantage: fuel cells are expensive, require specialized catalysts etc *

c Fuel cells generate electrical energy continuously while secondary cells require input of electrical energy to recharge them. *

(2 + (1 + 1) + 1 = 5 marks)

END of ANSWERS