MATRIC PHYSICAL SCIENCE PAPER 2 (2009): MEMORANDUM

SECTION A

QUESTION 1: ONE-WORD ITEMS

1.1 functional (group)
1.2 carbonyl
1.3 activation
1.4 electrolytic
1.5 anode [5 x 1 = **5**]

QUESTION 2: FALSE STATEMENTS

NOTE: Red indicates changes to make statements true.

2.1 The eutrophication of fresh water is caused by high concentrations of nitrate ions from highly soluble nitrate salts in fertilisers; the resulting algal blooms that thrive on the nitrates lower the oxygen concentration of the water.
2.2 An electrolytic cell is an electrochemical cell that converts electrical energy into chemical energy.
2.3 The Ostwald and Contact processes are used in the chemical industry to produce important industrial acids.
2.4 Strong reducing agents release electrons easily and improve the reducing ability of chemical species that receive the liberated electrons.
2.5 A bag of fertiliser marked 2:3:2 (28) indicates that nitrogen, phosphorus and potassium are present in the ratio of 8%:12%:8% of the total mass of fertiliser in the bag. [5 x 2 = **10**]

QUESTION 3

3.1 C
3.2 B
3.3 A
3.4 D
3.5 D [5 x 2 = **10**]

TOTAL FOR SECTION A: [25]

SECTION B

QUESTION 4

4.1.1 F
4.1.2 B
4.1.3 A
4.1.4 D [4 X 2 = **8**]

4.2.1 G (2)
4.2.2 fractional distillation (1)
4.2.3 F (1)
[**4**]

4.3.1 **2** C_2H_6 **+ 7** O_2 **→ 4** CO_2 + **6** H_2O (3)

4.3.2 Combustion of a hydrocarbon in oxygen/air (1)

4.3.3 $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
1 mole methane produces 1 mole carbon dioxide gas
24 g ≡ 24/(12 + 4) = 1,5 mol **→ 1,5 mol CO_2**
At S.T.P. 1,5 mol CO_2 occupies (1,5)(22,4) dm^3 = 33,6 dm^3 (4)
[8]

4.4.1 A chemical substance that changes the rate of a chemical reaction without undergoing any permanent change itself. (2)

4.4.2 H^+ ion (1)

4.4.3 B, D (2)

4.4.4 E (1)
[6]

4.5.1 Organic molecules containing *double bonds* are termed *unsaturated* because the carbons are not bound to the maximum number of hydrogens, i.e. they are not *saturated*. *Addition* reactions involve saturating the two double-bonded carbon atoms. (2)

4.5.2 The Van der Waals forces between (crystalline) fat molecules increase. (3)

4.5.3 cyclohexane (3)

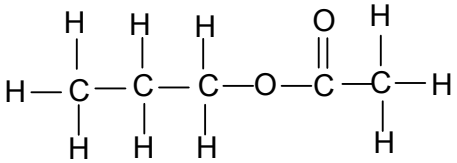
4.5.4 No, they are equivalent, depending on which way around the ring molecule one numbers the carbon atoms. (3)
[11]

4.6.1 carboxylic acid. (1)

4.6.2 ethanoic acid (1)

4.6.3 Propanoic acid. For a lower vapour pressure we require an acid with a higher molecular mass; the next more massive acid to ethanoic acid (the acid used in B) is propanoic acid. (2)

4.6.4 propyl ethanoate



(5)
[9]

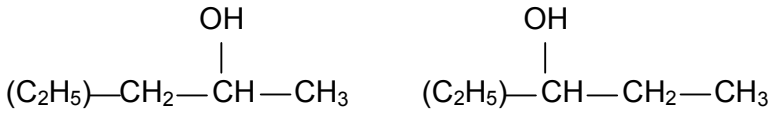
4.7.1 Presence of MULTIPLE bonds (double and triple) (2)

4.7.2 Because the hydrogen will always attach to the previously most substituted carbon, i.e. the one that had the most hydrogens bound before the reaction. (This is known as Markownikoff's rule.) (3)

4.7.3 2-bromo-2-methyl propane. (2)
[7]

4.8.1 *Isotopes* are nuclei of the same element (i.e. same atomic number, Z) but with different numbers of neutrons and hence different mass numbers (A).
Structural isomers are molecules with the same molecular formulae, but which are structurally different. (3)

4.8.2



2-pentanol 3-pentanol (4)
[7]

4.9 3-hexanol and sodium bromide (4)
[4]

[64]

QUESTION 5

5.1 $2H_2 + O_2 \rightarrow 2H_2O$
$2(436) + (494) \rightarrow (2)(2)(460)$
1366 kJ mol^{-1} used (endothermic) to break the bonds;
1840 kJ mol^{-1} released (exothermic) when new bonds are formed;
$\therefore$ nett (1840 – 1366) = 474 kJ mol^{-1} released (exothermic)

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
$4(414) + 2(494) \rightarrow (2)(707) + (2)(2)(460)$
2644 kJ mol^{-1} used (endothermic) to break the bonds;
3254 kJ mol^{-1} released (exothermic) when new bonds are formed;
$\therefore$ nett (3254 – 2644) = 1210 kJ mol^{-1} released (exothermic) (5)

5.2 The *fuel* is the source of energy, whereas the oxidiser is the chemical that promotes the breaking of bonds in the fuel and hence the formation of other bonds by the atoms in the fuel. (2)

5.3 2 moles of H_2 lead to the release of 474 kJ
$\therefore$ 1 mole of H_2 leads to the release of 237 kJ
$\therefore$ 1 kg (≡ 1000/2 mol) = 500 moles of H_2 lead to the release of 500 x 237 kJ
= 11,85 x 10^4 kJ

1 mole of CH_4 leads to the release of 1210 kJ
$\therefore$ 1 kg (≡ 1000/16 mol) = 62,5 moles of CH_4 leads to release of 62,5 x 1210 kJ
= 7,56 x 10^4 kJ (< $\Delta H_{hydrogen}$) (3)
[10]

QUESTION 6

6.1.1 High temperatures favour the reverse reaction, but also raise the rate of reaction. (3)

6.1.2 There are 4 moles of reactants and only 2 moles of product; all are gases. Therefore high pressure favours the forward reaction (according to Le Châtelier: equilibrium moves in the direction that removes stress on system) (3)

6.1.3 High temperature to increase reaction rate; high pressure to shift equilibrium to the right. 500/600 temperature–pressure combination is optimal because although high temperature increases reaction, rate it also favours the reverse reaction. (2)

6.2.1

$V = 2\ dm^3$	N_2	H_2	NH_3
Mole ratio (n)	1	3	2
n (moles at start)	3	6	0
n (moles used)	1,5	4,5	
N (moles at ≡ ium)	1,5	1,5	3
concentration at ≡ ium	0,75	0,75	1,5

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{[1,5]^2}{[0,75][0,75]^3} = \frac{[1,5]^2}{[0,75][0,75]^3} = 7,11 \qquad (6)$$

6.2.2 The forward reaction is exothermic. When the temperature is raised (to 500 K) it favours the reverse reaction, i.e. product reforms reactants, hence concentration of ammonia drops and K_c decreases. (3)

[17]

QUESTION 7

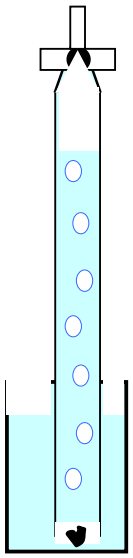
7.1 carbon dioxide (1)

7.2 $H_2SO_3 + CaCO_3 \rightarrow CaSO_3 + H_2O + CO_2$ (2)

7.3.1 How fast does acid rain (consisting of weak sulphurous acid) dissolve marble? (1)

7.3.2 Weak sulphurous acid will not dissolve marble. (1)

7.3.3 The best method will be to place the small marble chip in the beaker, cover it with sulphurous acid and then invert the burette, which has been filled with the acid, and place the open end of the burette over the marble chip. In this way, if it is done quickly, any and all gas produced in a reaction, will be caught in the burette where the volume of gas can be measured at regular intervals. ,A rate of reaction, if any, can be calculated from the time and gas volume data. (4)



7.3.4 Concentration of acid. (if the acid in the beaker is kept topped up, the small amount of marble will not change the acid concentration appreciably.) (1)

7.3.5 The rate at which a certain concentration of sulphurous acid will decompose marble. The rate of decomposition, if any occurs, can be measured by the volume of carbon dioxide gas produced. (1)

7.3.6 Estimates of the SO_2 concentration in the air, the resulting acidity of rain water, the annual rainfall in the affected areas, and the results of the investigation that will enable an estimate of the rate of decay of exposed marble to be made. (1)

[12]

QUESTION 8

8.1 Needle deflects left and right so the direction will indicate direction of charge flow (and hence which is the oxidising- and which the reducing half cell). (1)
8.2 salt bridge (1)

8.3.1 left (1)
8.3.2 left (1)

8.4 silver (Ag) (1)

8.5.1 The iron electrode will decompose and Fe^{2+} ions will go into solution. (2)
8.5.2 $Fe + Ag^{+} \rightleftharpoons Fe^{2+} + Ag$ (2)
8.5.3 $E^{0} = E_{reduced} – E_{oxidized} = 0,80 – (-0,44) = +1,24$ V (3)

8.6. The E^{0} values on the Standard Reduction Table are measurements made for standard conditions where solutions have a concentration of 1 mol dm^{-3}. As the cell runs down, the concentrations of metal ions increase (for the reductant) and decrease (for the oxidant). The half cell equilibria shift and the half cell reduction potentials tend towards zero.

(2)
[15]

QUESTION 9

9.1 NaOH (sodium hydroxide) (1)
9.2.1 anode (1)
9.2.2. cathode (1)
9.3 $2Na + 2H_2O \rightarrow (2Na^{+} + 2H^{+} + 2OH^{-}) \rightarrow 2NaOH + H_2$ (2)
9.4.1 Asbestos. Diaphragms made of fibrous asbestos can contribute to debilitating lung disease, asbestosis. (1)
9.4.2 Mercury. It causes heavy metal poisoning and remains in ecosystems because it is very difficult to remove. (1)
[7]

TOTAL FOR SECTION B: 125

GRAND TOTAL: 150