2015 UNIT 3/4 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 [30 × 1 = **30**]

1. D	2. D	3. A	4. C	5. B	6. D	7. C	8. A	9. D	10. A
11. B	12. C	13. B	14. A	15. B	16. C	17. D	18. B	19. A	20 B.
21. A	22. A	23. D	24. C	25. A	26. D	27. B	28. C	29. D	30. B

SECTION B [total = 100 marks] * = 1 mark

Question 1 (10 marks)

a. i. $K = [CO_2]x[H_2]^4 / [CH_4]x[H_2O]^2$ 1 mark

ii. * = 1 mark (3 x 1 = **3 marks**)

	CH_4	$2H_2O$	CO_2	$4H_2$
initial	1	1.4	0	0
change	1-0.22	1.4 – 0.44	0.22	0.88*
equilibrium	0.78*	0.96*		

iii. $K = [0.22]x[0.88]^4 / [0.78]x[0.96]^2$ *
$= 0.78 \text{ x } 0.5997 / 0.78 \text{ x } 0.9216 = 0.132 / 0.719 =$ **0.18 M^2** (2 sig fig) * 2 marks

b. 4 x 1 = **4 mark**

True (1 mol of methane will form 1 mol CO_2)
False (It is a reversible reaction)
False (In a reversible reaction, some reactant will remain)
False (not all the methane will react)

Question 2 (8 marks)

a i. The value of ΔT will be lower than that of a well insulated calorimeter. **1 mark**

ii. The calibration factor will be higher than that of a well-insulated calorimeter due to $c_f \sim 1 / \Delta T$.

1 mark

b.i. $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$ **1 mark**

ii. The number of mole of HCl must be used as it is the limiting reagent in this experiment. **1 mark**

c i. The value of ΔT will be lower than it should be as more water is being heated. **1 mark**

ii. the value of ΔH will be lower than it should be as a result of the low ΔT **1 mark**

d. $n(\text{ethanol}) = \frac{0.552}{46} = 0.012$ mol

$E = n \times 1364 = 0.012 \times 1364 = 16.368$ kJ = 16368 J *

$\Delta T = E/CF = 16368/684 = 23.9\ ^0\text{C}$ * **2 marks**

Question 3 (5 marks)

a. $n(\text{HCl})$ initially = $c \times V = 0.250 \times 100.0 \times 10^{-3} = 0.0250$ mol 1 mark

$n(\text{HCl})$ unreacted = $n(\text{NaOH}) = c \times V = 0.375 \times 17.80 \times 10^{-3} = 0.006675$ mol 1 mark

$n(\text{HCl})$ used in reaction = $n(\text{HCl})$ initially – $n(\text{HCl})$ unreacted

= 0.0250 – 0.006675 = 0.0183 mol 1 mark

b. For example: the grain may contain other basic substances that react with the HCl 1 mark

c . Ammonia is a volatile gas which may escape from the solution during titration. Reacting with excess HCl prevents this loss. 1 mark

Question 4 (11 marks)

mass ratio in 100 g of compound C : H : O = 41.4 g : 3.4 g : 55.2 g a.

mol ratio = $\left(\frac{41.4}{12}\right) : \left(\frac{3.4}{1.0}\right) : \left(\frac{55.2}{16}\right)$ 1 mark

= 3.45 : 3.4 : 3.45

= 1 : 1 : 1

So the empirical formula is CHO. 1 mark

b. The molecular ion has m/z of 116 and so M(compound) = 116 g mol^{-1}. 1 mark

M(CHO) = 29 and so there are $\frac{116}{29}$ units of CHO in the molecule.

So the molecular formula is $C_4H_4O_4$. 1 mark

c i. X: O-H in acids (2500 to 3300 cm^{-1}) 1 mark

ii. Y: C=C (1610 to 1680 cm^{-1}) 1 mark

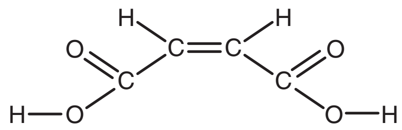
d)

$n(\text{KOH}) = \frac{5.05}{56.1} = 0.090$ mol 1 mark

$n(\text{compound}) = 0.045 = \frac{1}{2} \times n(\text{KOH})$

The compound can donate two protons per molecule and so each molecule has two acidic (carboxyl) groups. 1 mark

e)



2 marks

1 mark for showing all bonds

1 mark for showing C=C and –COOH groupings

f.

There are two carbon environments shown on the ^{13}C NMR spectrum:

- the peak at 165 ppm corresponds to –COOH in the compound 1 mark
- the peak at 130 ppm corresponds to –C=C– in the compound 1 mark

Question 5 (11 marks)

a. $n(\text{linoleic acid}) = \frac{m}{M} = \frac{15.89}{280.0}$ mol 1 mark

The formula C_nH_{2n-3} indicates that linoleic acid contains two C=C bonds (or use the equation $C_{17}H_{31}COOH + 2H_2 \rightarrow C_{17}H_{35}COOH$).

So $n(H_2) = 2 \times n(\text{linoleic acid}) = 2 \times \frac{15.89}{280.0}$ mol 1 mark

$V(H_2) = \frac{nRT}{P} = \frac{2 \times 15.89 \times 8.31 \times 323}{280.0 \times 1.2 \times 101.3} = 2.51$ L 2 marks

1 mark for formula and unit conversions

1 mark for correct volume

b. i. linoleic acid 1 mark

It has the *higher concentration* as it has the *larger area under the peak* 1 mark

- do not award marks if peak height is used to explain the higher concentration

ii. stearic acid 1 mark

Both fatty acids are largely non-polar and will interact with the non-polar stationary phase via dispersion forces.

However, stearic acid was more adsorbed to the stationary phase (longer retention time) 1 mark

Therefore bc it has stronger dispersion forces it would have a higher melting point, as a greater amount of energy is needed to disrupt the intermolecular bonding. 1 mark

c. The esters would be vaporise at lower temperature (*because the esters are more volatile than the carboxylic acids)* 1 mark

Question 6 (7 marks)

a. i. ether (or glycosidic) linkage 1 mark

ii. hydrolysis 1 mark

The microbes do not use oxygen (anaerobic) to produce the alkanols and are unable to function in an atmosphere of oxygen. 1 mark

I would also accept oxidation to carboxylic acid???

b. **i**. $E = \text{C.F.} \times \Delta T = 3.49 \times 5.16 = 18.01$ kJ 1 mark

$n(\text{biobutanol}) = \dfrac{m}{M} = \dfrac{0.498}{74.0} = 0.006729$ mol

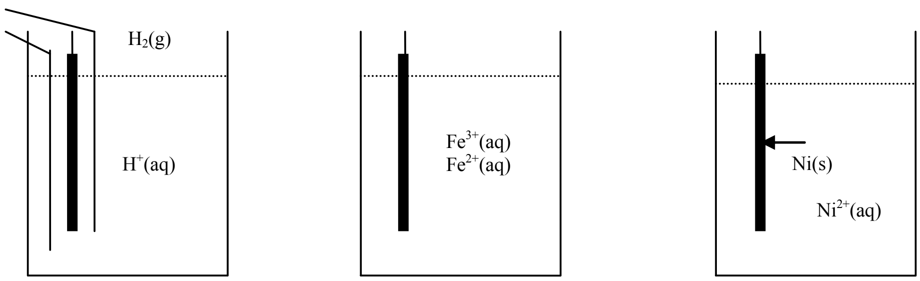
energy released per mol $= \dfrac{18.01}{0.006729} = 2676$ kJ $= 2.68 \times 10^3$ kJ 1 mark

ii. $C_4H_9OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$ * $\Delta H = -2.68$ MJ mol^{-1} 2 marks

1 mark for correctly balanced equation

1 mark for correct ΔH and sign

Question 7 (8 marks)



A **B** **C**

a. **i**. Beaker A: $2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$

ii. Beaker B: $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ See diagram above***

iii. Beaker C: $Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$

iv. $Fe^{3+}(aq)$ * (See Data Booklet)

v. Beakers B and C* (See Data Booklet)

1 + 1 + 1 + 1 + 1 = 5 marks

b.

In this cell, the

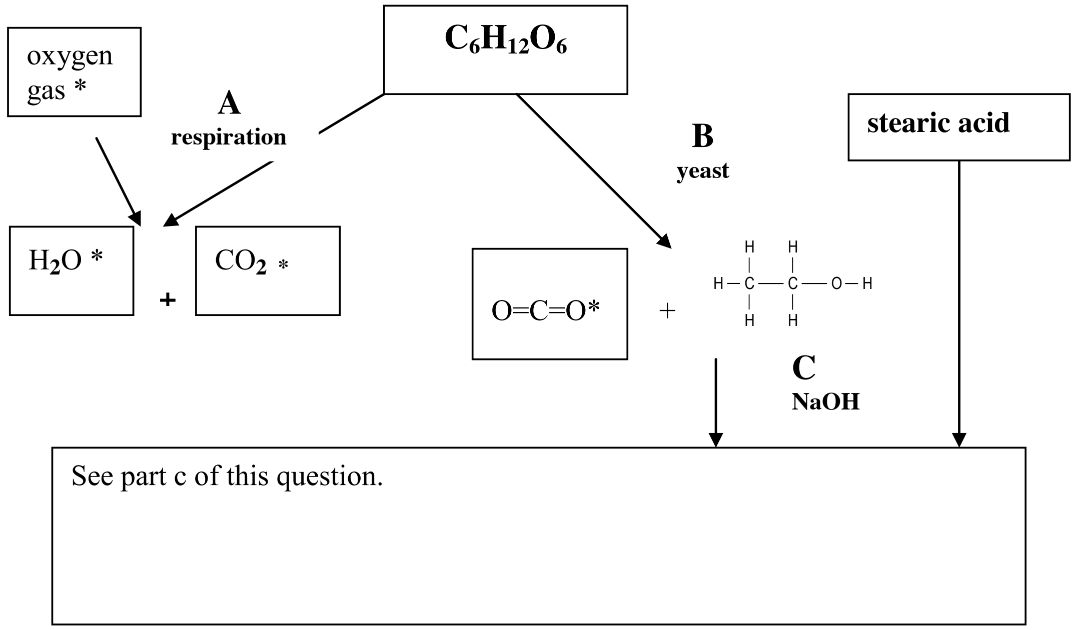
i. positive electrode will be $Fe^{3+}(aq)$ half cell electrode*

ii. $Fe^{3+}(aq)$ *

iii. electrons will flow from beaker C to beaker B*

2 + 1 + 1 = 3 marks

Question 8 (12 marks)



a. **i**. See diagram

ii. See diagram

2 + 1 = 3 marks

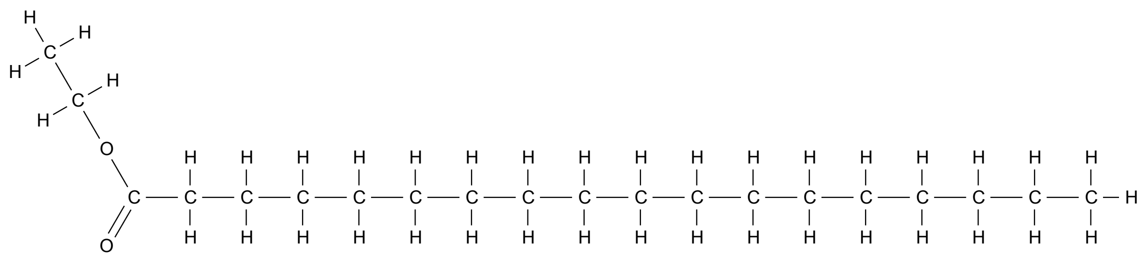
b. i. $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2\ CO_2(g)$ 1 mark

ii. see diagram 2 marks

iii. enzymes in yeast *act as a catalyst* 1 mark

iv. enzymes in yeast are heat sensitive. The active site is changed and their ability to function is destroyed 1 mark

c. i.



17 carbons plus the –$COOC_2H_5$ *1 mark*

ii. the reactant is sourced from plant material, they are renewable and can be replenished as rapidly as they are used 1 mark

iii. M(stearic acid) = M($C_{17}H_{35}COOH$) = 12 x 17 + 35 + 12 + 32 + 1) = 284

$$n = \frac{100000}{284} = 352.1 mol\ *$$

n(stearic acid) =n(biodiesel) = 352.1mol

mass = $nxM = 352.1 \times 312 = 110 kg$ *

2 marks

Question 9 (8 marks)

a. i. $Cr_2O_7^{2-}$ (aq) + $14H^+$(aq) + $6e^-$ → $2Cr^{3+}$(aq) + $7H_2O$(l) 2 marks

1 mark for correctly balanced half equation
½ mark each for states and electrons on correct side

ii. reduction 1 mark

b. i. permanent colour change from orange to green 1 mark

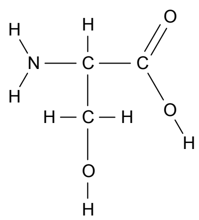
ii. ratio of Fe^{2+} : $Cr_2O_7^{2-}$ (aq) = 6 : 1, therefore 6 x 5400 = 32400 1 mark

c. i. The original $Cr_2O_7^{2-}$ solution is orange. This means it absorbs blue light but reflects yellow and red. Hence the wavelength is set to a blue colour. 1 mark

ii. As the reaction proceeds, the absorption should decrease because the concentration of the $Cr_2O_7^{2-}$ is decreasing. 1 mark

Question 10 (7 marks)

a. **i**. *



ii. serine*

iii. carboxyl, hydroxyl, amine *

1 + 1 + 1 = 3 marks

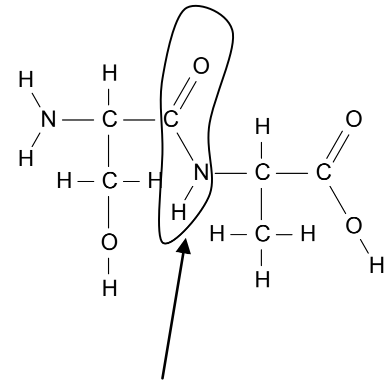
b.

```
          O- H
           |
       H – C – H
       H   |
       |   |
   H – N+ –C – C = O
       |   |   |
       H   H   O-
```

2 marks

1 mark for correct structure
1 mark for correct charge on N- atom of amine group and O- atom from carboxyl group (not hydroxyl)

c. **i**.



1 mark

*

ii. peptide (or amide) link

1 mark

Question 11 (6 marks)

1 mark each per reaction

a. Cell A: Molten KCl — 2 marks

- the cathode: $K^+(l) + e^- \rightarrow K(l)$
- the anode: $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$

b. Cell B: Dilute KCl solution — 2 marks

- the cathode: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
- the anode: $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

c. Cell C: 4.0 M KCl solution — 2 marks

i.

- the cathode: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
- the anode: $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$

Question 12 (8 marks)

a. **i.** $K_a = \dfrac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$ 1 mark

ii. $[H_3O^+] = 10^{-pH} = 10^{-3.38} = 4.17 \times 10^{-4}$ M 1 mark

$$K_a = 1.7 \times 10^{-5} = \frac{(4.17 \times 10^{-4} \times [CH_3COO^-])}{[CH_3COOH]}$$

$\%\ \text{ionisation} = \dfrac{[CH_3COO^-]}{[CH_3COOH]} \times 100$ 1 mark

$= \dfrac{1.7 \times 10^{-5}}{4.17 \times 10^{-4}} \times 100 = 4.1\%$ 1 mark

b. $[H_3O^+][OH^-] = 10^{-14} = 10^{-2.56} \times [OH^-]$ 1 mark

$[OH^-] = 3.63 \times 10^{-12}$ M 1 mark

c. $c_1V_1 = c_2V_2 = 10^{-2.00} \times 0.0100 = 10^{-2.37} \times V_2$

$V_2 = \dfrac{10^{-4}}{10^{-2.37}} = 2.34 \times 10^{-2}$ L = 23.4 mL 1 mark

Thus the volume of water added = 23.4 – 10.0 = 13.4 mL. 1 mark