

CHEMISTRY

Unit 4 – Written examination 2



2011 Trial Examination

SOLUTIONS

SECTION A – Multiple-choice questions (1 mark each)

Question 1

Answer: D

Explanation:

When the reaction is reversed, the sign of ΔH is changed but the magnitude is not. Therefore ΔH is +91. The value of K becomes the reciprocal. The reciprocal of 12.5 is 0.08.

Question 2

Answer: A

Explanation:

The reaction is exothermic so an increase in temperature leads to a lower yield. A decrease in pressure also favours the reverse reaction because there are more products than reactants.

Question 3

Answer: C

Explanation:

HCl is a strong acid and HCN is a very weak acid. Even though the volume of HCN is greater, the concentration of H_3O^+ is much less, making the pH higher.

Question 4

Answer: A

Explanation:

In a solution of 0.005 M $\text{Ba}(\text{OH})_2$ the OH^- concentration is $2 \times 0.005 = 0.01 = 10^{-2}$.
Therefore the $[\text{H}_3\text{O}^+] = 10^{-2} \Rightarrow \text{pH} = 12$

Question 5

Answer: B

Explanation:

The $[\text{OH}^-]$ is increasing with temperature. This means that K_w is also increasing. If K_w is increasing with temperature, the reaction must be endothermic.

Question 6

Answer: C

Explanation:

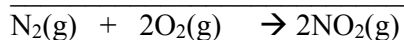
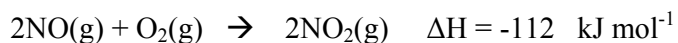
As the temperature increases, the yield drops. This matches an exothermic reaction. As the pressure increases the yield increases. This occurs if the forward reaction is favoured. This occurs if there are less product molecules than reactants.

Question 7

Answer: B

Explanation:

Conventional nuclear power stations use fission reactions where large uranium or plutonium nuclei are split. Radioactive waste is produced during this process. The electrons are irrelevant to the question.

Question 8*Answer:* B*Explanation:*

The overall equation required is formed from the first equation provided and the second equation reversed. ΔH is therefore $180 - 112 = +68$

Question 9*Answer:* A*Explanation:*

The energy required will be

$$E = 4.18 \times m \times \Delta T = 4.18 \times 100 \times 40 = 16720 \text{ J}$$

From Data book, 1 mole ethanol = 1364 kJ

$$n(\text{ethanol}) = \frac{16720}{1364000} = 0.0123 \text{ mol}$$

$$\text{mass} = n \times M = 0.0123 \times 46 = 0.566 \text{ g}$$

Question 10*Answer:* D*Explanation:*

Coal contains carbon and sulphur. Both of these burn to form carbon dioxide and sulphur dioxide. At the high temperatures, nitrogen in air also reacts to form NO. The NO reacts further to NO₂

Question 11

Answer: A

Explanation:

Catalysts used are also catalysts for the reverse reactions. If the products are kept at high temperatures for a long time, the likelihood of back reactions or side reactions occurring is increased.

Question 12

Answer: A

Explanation:

$$E = 4.18 \times m \times \Delta T = 4.18 \times 1000 \times 20 = 83600 \text{ J}$$

Each fuel needs to be tested one by one against the molar values given in the Data book.

$$\text{Methanol: } n = \frac{83600}{725000} = 0.115 \text{ mol}$$

Question 13

Answer: B

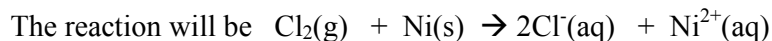
Explanation:

The reaction is very exothermic. As it proceeds, the temperature of the container increases. At the higher temperatures, the rate of the reaction will increase.

Question 14

Answer: B

Explanation:



This makes nickel the negative electrode. Electrons will leave here and travel to the chlorine half cell.

Question 15

Answer: D

Explanation:

The overall equation is given in the previous question

Question 16

Answer: C

Explanation:

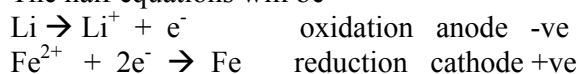
Manganese ions are the only option that is below the water half equation at -0.8 volts. The water will react instead of the manganese

Question 17

Answer: A

Explanation:

The half equations will be



Question 18

Answer: C

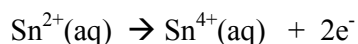
Explanation:

The reaction occurring in the iron cell during recharge will be $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$
This is oxidation. Oxidation will be at the anode and the anode is positive during electrolysis

Question 19

Answer: D

Explanation:



The only feasible half equation is D.

Platinum is inert, Sn(s) is not present. Half equation C is not balanced correctly.

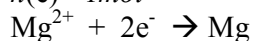
Question 20

Answer: B

Explanation:

$$Q = It = 4 \times 24125 = 96500 \text{ C}$$

$$n(\text{e}) = 1 \text{ mol}$$

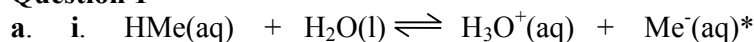


$$n(\text{Mg}) = 0.5$$

SECTION B: Short answer questions

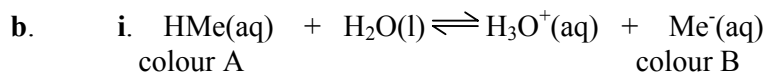
*An * indicates the allocation of 1 mark*

Question 1

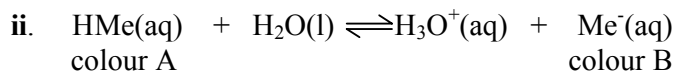


ii. Most indicators have a different colour between the acid and its conjugate, in this case between the HMe and the Me⁻*

1 + 1 = 2 marks



As the $[\text{H}_3\text{O}^+]$ concentration increases the reverse reaction is favoured, producing more of colour A *



As the $[\text{OH}^-]$ concentration increases, it reacts with the H_3O^+ to produce water. The forward reaction is favoured, producing more of colour B *

1 + 2 = 3 marks

c. i. $K_a = \frac{[\text{H}_3\text{O}^+][\text{Me}^-]}{[\text{HMe}]}$ *

ii. If $[\text{HMe}] = [\text{Me}^-]$

$$K_a = \frac{[H_3O^+][Me^-]}{[HMe]} \quad \text{becomes} \quad K_a = [H_3O^+] \quad *$$

iii. $K_a = [H_3O^+] = 2 \times 10^{-4}$
 $pH = -\log 2 \times 10^{-4} = 3.7 *$

1 + 1 + 1 = 3 marks

Total 8 marks

Question 2

	Beaker A	Beaker B	Beaker C
$[\text{H}_3\text{O}^+]$	Strong acid $\Rightarrow 0.01$	$1.7 \times 10^{-5} = \frac{X \times X}{0.01}$ $X = 4.1 \times 10^{-4}$	Strong base $\Rightarrow 10^{-12}$
$[\text{OH}^-]$	$\frac{10^{-14}}{0.01} = 10^{-12}$	$\frac{10^{-14}}{4.1 \times 10^{-4}} = 2.4 \times 10^{-11}$	0.01
K_w	10^{-14}	10^{-14}	10^{-14}
pH	2	3.38	12

½ mark in this column

1 mark in this column

½ mark in this column

Total 8 marks

Question 3

- a. i. From the 1 minute mark to the 5 minute mark = 4 minutes*
The temperature is increasing consistently during calibration.

$$\text{ii. } CF = \frac{VIt}{\Delta T} = \frac{3.6 \times 5.8 \times 4 \times 60}{3.2} = 1570 J^{\circ}C^{-1} \quad **$$

(answers will vary with reading of graph)

1 + 2 = 3 marks

- b. i. The temperature change should be double*
- ii. It should be unchanged*. The temperature change is greater but the energy input is also greater *

1 + 2 = 3 marks

- c. i. 6.5 °C (depending upon reading of graph)*

$$\text{ii. } E = CF \times \Delta T = 1570 \times 6.5 = 10205 J^*$$

$$n(\text{CuSO}_4) = \frac{5}{159.5} = 0.0313 \text{ mol}^*$$

$$\Delta H = \frac{10205}{0.0313} = -326 \text{ kJ mol}^{-1}^*$$

1 + 3 = 4 marks
Total 10 marks

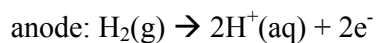
Question 4

- a. i. $\text{CH}_3\text{OH(g)} + \text{H}_2\text{O(g)} \rightleftharpoons \text{CO}_2\text{(g)} + 3\text{H}_2\text{(g)}^*$
- ii. High pressure will favour the reactants as there are less molecules of reactant than product*. The high pressure does however help the reaction rate.
- iii. High temperatures require energy. Less electrical energy is derived if some energy is needed to maintain a high temperature*. High temperatures in a vehicle can be dangerous.* High temperatures will lower the yield as the reaction is exothermic.

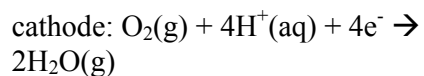
1 + 1 + 2 = 4 marks

b.

i.



* ii. *

iii. The overall equation is $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$

1 + 1 + 1 = 3 marks

c. i. Name two waste materials formed in this cell. Water and carbon dioxide *

ii. Water is not a concern, although the streets might be permanently wet! Carbon dioxide adds to the greenhouse issues.

1 + 1 = 2 marks

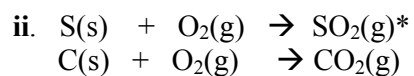
d. Fuel cells are not recharged – a continuous supply of reactants is used*

1 mark

Total 10 marks

Question 5

a. i. Steam, carbon dioxide, sulphur dioxide, nitrogen oxides, carbon monoxide**



1 + 1 = 2 marks

b. i. in the generator? mechanical $\rightarrow$ electrical *ii. in the boiler chemical potential $\rightarrow$ thermal *

1 + 1 = 2 marks

c. Increase the surface area to make the reaction rate higher.* Helps dry the coal

1 mark

d. Coal takes millions of years to form hence it is not considered renewable*

1 mark

Total 6 marks

Question 6

a.

	cell A	cell B
anode: half equation	$2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$	$2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$
cathode: half equation	$\text{Mg}^{2+}(\text{l}) + 2\text{e}^- \rightarrow \text{Mg}(\text{l})$	$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$
products	$\text{Mg}(\text{l}), \text{Cl}_2(\text{g})$	$\text{H}_2, \text{O}_2, \text{H}^+(\text{aq}), \text{OH}^-(\text{aq})$

1 mark each cell

6 marks

b.

Species	number of mole produced
magnesium	2.2 mole from cell A as Mg^{2+}
chlorine gas	2.2 mole from cell A as Cl_2
oxygen gas	1.1 mole from cell B as O_2
hydrogen gas	2.2 mole from cell B as H_2

1 mark each cell

4 marks

c. Total gas = oxygen + hydrogen + chlorine = $1.1 + 2.2 + 2.2 = 5.5$ mole *

$$V = n \times 22.4 \text{ at STP} = 5.5 \times 22.4 = 123 \text{ L} *$$

2 marks

Total 12 marks

Question 7

a. i. No. A lower figure will be reached as this reaction is reversible hence all of the reactants are not used*

ii. 3.2 mole of CO must have reacted therefore $10 - 3.2$ remains = 6.8 mole*

1 + 1 = 2 marks

b. i. No. The K value for the reverse reaction is very low. The level of CO will be very low*.

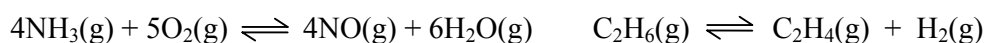
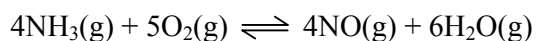
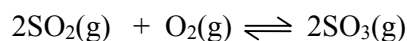
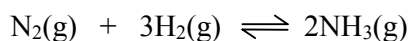
ii. The sealed room makes a big difference. The engine running will use up significant oxygen so the concentration will be very low. There is so little oxygen left the forward reaction is limited leaving CO levels still dangerously high. *

1 + 1 = 2 marks

c. Add air to the room*
Decrease the temperature*
Increase the pressure*

3 marks

Total 7 marks

Question 8

a. Vary with eqn i.e.

$$K = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

1 mark

b. i. This will lead to an improved yield in all but ethene*

- ii. ammonia – higher yield
 SO₃ – higher yield
 nitrogen oxide – lower yield
 ethene – lower yield*

iii. no impact on yield*

1 + 1 + 1 = 3 marks

- c. ammonia: 400-450 °C and 200 atm
 SO₃: 400 °C and 1 atm
 ethene: 1 atm and 1000 °C
 nitric acid: 900 °C and 4-10 atm **

2 marks

d. i. Danger of explosions and high cost of quality equipment **

ii. A leak will draw air into the reactor - chance of explosions*

2 + 1 = 3 marks

- e. ammonia: pungent gas, corrosive
 nitric acid: corrosive, toxic
 sulfuric acid: corrosive, toxic
 ethene: flammable, toxic *

1 mark

Total 10 marks