CHEMISTRY

Unit 4 – Written examination 2

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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 $Ba(OH)_2$ the OH^- concentration is 2 x 0.005 = 0.01 = 10^{-2}.
Therefore the $[H_3O^+] = 10^{-2}$ => pH = 12

Question 5

Answer: B

Explanation:
The $[OH^-]$ 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.

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Question 8

Answer: B

Explanation:

$N_2(g) + O_2(g) \rightarrow 2NO(g) \quad \Delta H = +180 \text{ kJ mol}^{-1}$

$2NO(g) + O_2(g) \rightarrow 2NO_2(g) \quad \Delta H = -112 \text{ kJ mol}^{-1}$

$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$

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

From Data book, 1 mole ethanol = 1364 kJ

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

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

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 NO_2

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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:

$E = 4.18 \times m \times \Delta T = 4.18 \times 1000 \times 20 = 83600\ J$
Each fuel needs to be tested one by one against the molar values given in the Data book.
Methanol: $n = \frac{83600}{725000} = 0.115 mol$

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:

The reaction will be $Cl_2(g) + Ni(s) \rightarrow 2Cl^-(aq) + Ni^{2+}(aq)$
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

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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
$Li \rightarrow Li^{+} + e^{-}$ oxidation anode -ve
$Fe^{2+} + 2e^{-} \rightarrow Fe$ reduction cathode +ve

Question 18

Answer: C

Explanation:

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

Question 19

Answer: D

Explanation:

$Sn^{2+}(aq) \rightarrow Sn^{4+}(aq) + 2e^{-}$
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:
$Q=It = 4 \times 24125 = 96500\ C$
$n(e) = 1 mol$
$Mg^{2+} + 2e^{-} \rightarrow Mg$
$n(Mg) = 0.5$

SECTION B: Short answer questions

*An * indicates the allocation of 1 mark*

Question 1

a. **i**. $HMe(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + Me^-(aq)$*

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

b. **i**. $HMe(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + Me^-(aq)$
colour A colour B
As the $[H_3O^+]$concentration increases the reverse reaction is favoured, producing more of colour A *

ii. $HMe(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + Me^-(aq)$
colour A colour B
As the $[OH^-]$ 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**. $K_a = \frac{[H_3O^+][Me^-]}{[HMe]}$ *

ii. If $[HMe] = [Me^-]$

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

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**
$[H_3O^+]$	Strong acid => 0.01	$1.7 \times 10^{-5} = \frac{X \times X}{0.01}$ $X = 4.1 \times 10^{-4}$	Strong base => 10^{-12}
$[OH^-]$	$\frac{10^{-14}}{0.01} = 10^{-12}$	$\frac{10^{-14}}{4.1 \times 10^{-4}} = 2.4 \times 10^{-11}$	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.

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

ii. $E = CF\ x\ \Delta T = 1570$ x $6.5 = 10205\ J$*

$n(CuSO_4) = \frac{5}{159.5} = 0.0313 mol$ *

$\Delta H = \frac{10205}{0.0313} = -326 kJmol^{-1}$ *

1 + 3 = 4 marks
Total 10 marks

Question 4

a. **i**. $CH_3OH(g) + H_2O(g) \rightleftharpoons CO_2(g) + 3H_2(g)$ *

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

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b.

i. anode: $H_2(g) \rightarrow 2H^+(aq) + 2e^-$ * **ii**. * cathode: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(g)$

iii. The overall equation is $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

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**

ii. $S(s) + O_2(g) \rightarrow SO_2(g)$*
$C(s) + O_2(g) \rightarrow CO_2(g)$

1 + 1 = 2 marks

b. **i**. in the generator? mechanical → electrical *

ii. in the boiler chemical potential → 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

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Question 6

a.

	cell A	cell B
anode: half equation	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$
cathode: half equation	$Mg^{2+}(l) + 2e^- \rightarrow Mg(l)$	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
products	$Mg(l)$, $Cl_2(g)$	H_2, O_2, $H^+(aq)$, $OH^-(aq)$

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 *

$V=n$x22.4 at STP = 5.5 x 22.4 = 123 *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

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Question 8

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$

a. Vary with eqn i.e.

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3} \quad *$$

1 mark

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

ii. ammonia – higher yield
SO_3 – 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
SO_3: 400 °C and 1 atm
ethene: 1atm 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

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