CHEMISTRY

Unit 3 – Written examination

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2020 Trial Examination

SOLUTIONS

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

Question 1

Answer: B

Explanation:

The reverse reaction has the same magnitude of ΔH but the sign is reversed (89.9 kJmol^{-1}) and the activation energy is increased to 114.6 kJmol^{-1} (24.7 + 89.9).

Question 2

Answer: D

Explanation:

n = V/24.8 = 1.2/24.8 = 0.04839 mol
0.04829 mol → 326 kJ
1 mol → 326/.04839 = 6737 kJ mol^{-1}

Question 3

Answer: A

Explanation:

The negative electrode in a fuel cell is the Anode, where oxidation occurs. CH_4 is oxidised at the anode.

Question 4

Answer: B

Explanation:

Fuel cells are much more efficient than internal combustion engines so less fuel is needed to obtain the same amount of energy.

Question 5

Answer: A

Explanation:

In an electrolysis cell the cathode is the negative electrode so reduction occurs. In liquid NaCl, Na^+ is reduced to Na at the cathode and Cl^- is oxidised to Cl_2 at the anode.

Question 6

Answer: D

Explanation:

The Fe^{3+} shifts the equilibrium to the right so the concentration of $Fe(SCN)^{2+}$ increases and the concentration of SCN^- decreases.

Question 7

Answer: B

Explanation:

When water is added to the equilibrium mixture the concentration of all species is decreased. The equilibrium then shift to the side of the equation with the greatest number of mole, in this case the reactants.

Question 8

Answer: C

Explanation:

Carbon dioxide is lost as a gas as it is produced.
$n(CaCO_3) = m/M = 1000/100 = 10$ mol.
$n(CO_2) = n(CaCO_3) = 10$ mol
$m(CO_2) = n \times M = 10 \times 44 = 440$g lost, so $1000-440 = 560$ g final mass

Question 9

Answer: D

Explanation:

A colliding particle at T_2 (the higher temperature) is more likely to react than a colliding particle at T_1. Not all particles at T_2 are moving faster than all of the particles at T_1. The activation energy does not change as the temperature is increased.

Question 10

Answer: B

Explanation:

The concentration of copper ions is constant as they are being consumed at the cathode and produced at the anode at the same rate.

Question 11

Answer: D

Explanation:

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$Q = It = 2.50$ x 60 x $60 = 9000$ C
$n(e\text{-}) = 9000/96500 = 0.09326$ mol
$n(Ag^+) = 0.09326$ mol, $M = m/n = 2.77/0.09326 = 29.7$
$n(Mg^{2+}) = 0.04663$ mol, $M = m/n = 2.77/0.04663 = 59.4$
$n(Al^{3+}) = 0.03109$ mol, $M = m/n = 2.77/0.03109 = 89.1$
$n(Sn^{4+}) = 0.02332$ mol, $M = m/n = 2.77/1.47$ x $10^{-3} = 118.8 =$ correct molar mass

Question 12

Answer: C

Explanation:

A, B and D all involve non-renewable sources of hydrogen. While chlorine production uses a lot of energy, the hydrogen is collected rather than wasted.

Question 13

Answer: D

Explanation:

C = n/ v so divide the mole of each substance by 2.

	NO$_2$	N$_2$O$_4$
I	0.125	-
C	0.1	0.05
E	0.025	0.05

$K = [N_2O_4] / [NO_2]^2 = 0.05 / 0.025^2 = 80M^{-1}$

Question 14

Answer: A

Explanation:

The extra oxygen drives the reaction between haemoglobin and oxygen to the right. Haemoglobin's concentration is reduced which drives the reaction between haemoglobin and carbon monoxide to the left.

Question 15

Answer: B

Explanation:

The equation is reversed and doubled so ΔH is given the reverse sign and doubled.

Question 16

Answer: B

Explanation:

There are 2 moles of CO$_2$ in A, about 5 moles of Ne in B, 3.3 moles of Ne in C and about 2.3 moles of CO$_2$ in D.

Question 17

Answer: A

Explanation:

HCl is not commonly used in fuel cells unlike the other 3 electrolytes.

Question 18

Answer: B

Explanation:

The electrodes in a fuel cell are often porous and act as catalysts to increase reaction rate

Question 19

Answer: D

Explanation:

The water added to methanol will evaporate while the methanol is burning, absorbing heat and slowing the reaction down. Reducing the amount of methanol will not slow down the rate of reaction although it will reduce the amount of heat produced. Increasing the temperature increases the rate of reaction and using a flat dish instead of a test tube will increase the rate of reaction as there is more surface area.
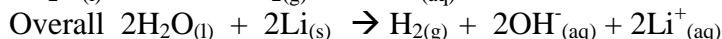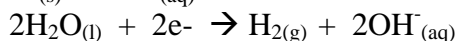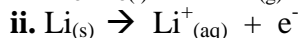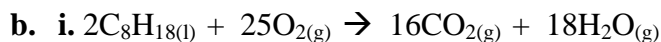
Question 20

Answer: C

Explanation:

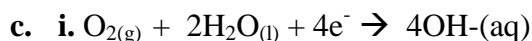Biofuels are not 100% carbon neutral as energy is used to produce and transport the fuels.

SECTION B: Short-answer questions

Question 1 (9 marks)

a. Internal combustion engines convert chemical energy to heat energy to kinetic energy. The conversion of chemical energy to heat energy is particularly inefficient. Electric motors convert chemical energy to electrical energy to kinetic energy and each conversion is quite efficient.

2 marks

b. **i.** $2C_8H_{18(l)} + 25O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O_{(g)}$
   ii. $Li_{(s)} \rightarrow Li^+_{(aq)} + e^-$
   $2H_2O_{(l)} + 2e- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$
   Overall $2H_2O_{(l)} + 2Li_{(s)} \rightarrow H_{2(g)} + 2OH^-_{(aq)} + 2Li^+_{(aq)}$

1 + 3 = 4 marks

c. **i.** $O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH-(aq)$
   ii. Air / oxygen is continually supplied and so doesn't need to be stored, allowing space for more Zinc.
   iii. The products need to remain in contact with the electrodes in a convertible form.

3 x 1 = 3 marks

Question 2 (6 marks)

a. $CH_3(CH_2)_{12}COOCH_3$
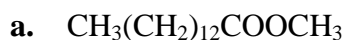
1 mark

b. 45 MJ/kg so 22.5 MJ in 500g

1 mark

c. A range of answer possible. For example;
   Biodiesel has a higher viscosity* as it has dipole to dipole bonds between molecules which are stronger than the dispersion forces between petrodiesel molecules.*
   Biodiesel has a higher cloud point as it has dipole to dipole bonds between molecules which are stronger than the dispersion forces between petrodiesel molecules.*
   Biodiesel is more hygroscopic* as it is polar and attracts water more strongly than non-polar petrodiesel molecules.* (any 2 properties and explanations)
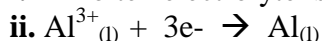
4 marks

Question 3 (12 marks)

a. Hydrogen does not need to be stored.

1 mark

b. **i.** A molten electrolyte is used as water is a stronger oxidant than Al^{3+}.
   ii. $Al^{3+}_{(l)} + 3e- \rightarrow Al_{(l)}$
   iii. Q = It = 20 000 x 20 x 60 = 24 000 000 C
   n = Q / 96 500 = 24 000 000/96 500 = 248.4 mol
   n (Al) = 248.4/3 = 82.9 mol
   m = n × M =82.9 x 27.0 = 2240 g = 2.24 kg

2 + 1 + 3 = 6 marks

c. 　**i.** $Al_{(l)} \rightarrow Al^{3+}_{(l)} + 3e^-$
　　ii. $2H_2O_{(l)} + 2e- \rightarrow 2OH-_{(aq)} + H_{2(g)}$

<div align="right">1 + 1 = 2 marks</div>

d. 　**i.** $O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH-(aq)$
　　ii. Hydroxide ions would move from the cathode (positive electrode) where they are produced to the anode (negative electrode)* where they would be consumed.*

<div align="right">1 + 2 = 3 marks</div>

Question 4 (11 marks)

a. 　$C_2H_5OH_{(g)} + 3O_{2(g)} \rightarrow 3H_2O_{(g)} + 2CO_{2(g)}$

<div align="right">1 mark</div>

b. 　$q = m \times c \times \Delta T$
　$q = 150 \times 4.18 \times (41.5-18)$
　$q = 14\ 730J$ for 0.873g*
　energy for 1 gram $= 14\ 730 / 0.873 = 16\ 900$ J or 16.9 kJ*

<div align="right">2 marks</div>

c. 　The experimental value is much less than the expected value of 29.6 MJkg^{-1} or 29.6 kJg^{-1}.*
　The experimental value is much lower due to heat loss through the air, container/lid and thermometer.*

<div align="right">2 marks</div>

d. 　Octane is much more flammable than ethanol (and the container may explode).

<div align="right">1 mark</div>

e. 　1 mol $\rightarrow$ 5460 kJ
　So 1000 kJ represents $1000/5460 = 0.1832$ mol *
　I mole of octane produces 8 mol of CO_2* so $n(CO_2) = 0.1832 \times 8 = 1.465$ mol *
　$V(CO_2) = n \times 24.8 = 36.3L$*

<div align="right">4 marks</div>

f. 　Ethanol is renewable so in theory the volume of CO_2 produced by combustion is similar to the volume of CO_2 consumed in producing the ethanol.

<div align="right">1 mark</div>

Question 5 (8 marks)

a. 　**i.** addition of CO
　ii. decrease in pressure (or increase in volume)
　iii. increase in temperature

<div align="right">3 x 1 = 3 marks</div>

b. 　$K = [CO_2] / [CO] [Cl_2]$ * $= 0.8 / 1.7 \times 0.7 = 0.67M^{-1}$ *

<div align="right">2 marks</div>

c. 　**i.** If CO is chosen. Carbon monoxide reacts with haemoglobin in the blood much more readily than oxygen so exposure to carbon monoxide means that less haemoglobin is available to bond with oxygen so a person could die from lack of oxygen.

　If Cl_2 is chosen. Chorine is a strong oxidant and respiratory irritant.* Exposure to chlorine could result in difficulties in breathing. *

　ii. The reaction should be carried out in a fume cupboard.*

<div align="right">2 + 1 = 3 marks</div>

Question 6 (7 marks)

a.
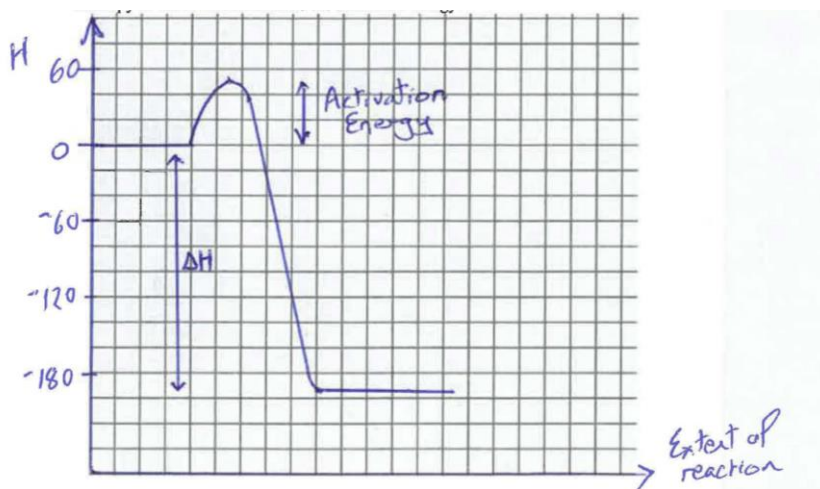
2 marks

b. **i.** increase

ii. decrease

2 x 1 = 2 marks

c. A high pressure would be used* as there are 2 mol of products and 3 mol of reactants. When pressure is increased the particles are pushed closer together. To partly compensate for the greater concentration of particles the equilibrium shifts to the products to decrease the concentration of particles.*

2 marks

d. No change.

1 mark