Question 1 – Reactions Rates Experiment

1.1 Sulphur ✓ (1)

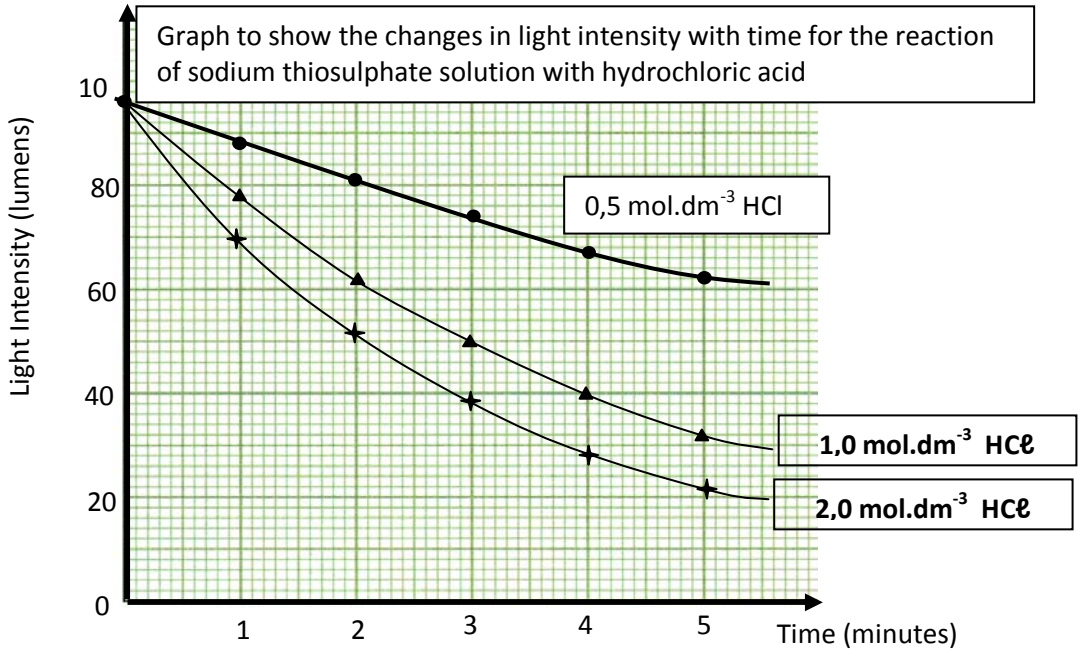
1.2 Concentration of HCℓ. ✓ (1)

1.3 Reaction rate ✓ (as measured by change in light intensity). (1)

1.4
- Concentration of $Na_2S_2O_3$(aq)
- Volume of $Na_2S_2O_3$ (aq)
- Volume of HCℓ (aq)
- Temperature
- Distance between light source & light meter.

Any 2 valid.✓✓ (2)

1.5



- ✓✓ points
- ✓✓ smooth best fit curves. (4)

1.6 As concentration increases reaction rate increases.✓✓ (2)

1.7 More molecules per unit volume✓ ∴ more successful collisions.✓ (2)

1.8.1 What is the effect of temperature on the rate of reaction between sodium thiosulphate and hydrochloric acid? ✓ (1)

1.8.2 The higher the temperature the faster the reaction rate.✓✓ (2)

1.8.3
- Measure a set volume of $Na_2S_2O_3$ into conical flask.✓
- Heat $Na_2S_2O_3$ solution to set temperature (eg 30°C).✓
- Place flask of $Na_2S_2O_3$ over piece of paper with cross on it.✓
- Add set volume of HCℓ & start stop watch.✓
- Time until cross disappears from sight when viewed from above.✓
- Repeat with different temperatures.✓ (6)

[22 marks]

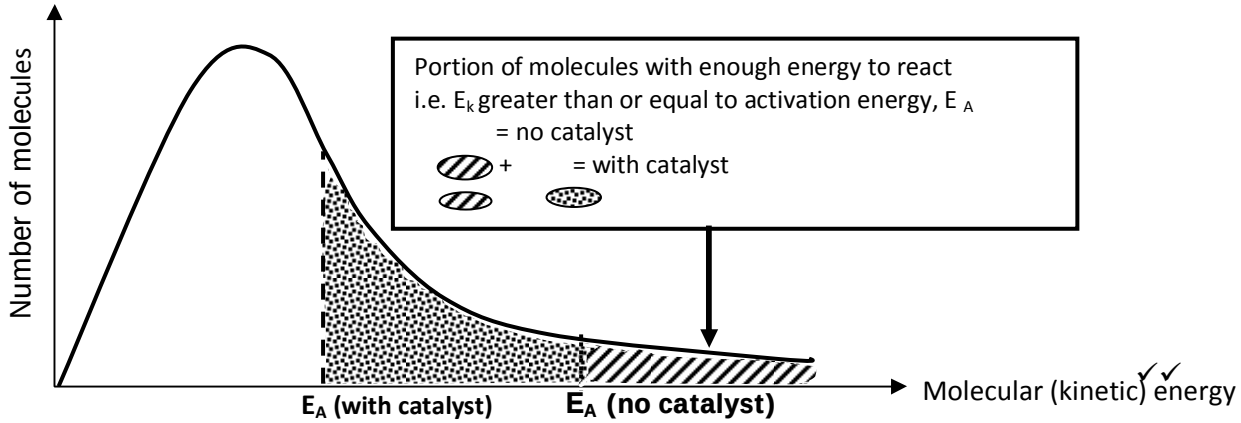
Question 2 – Industrial Chemical Reactions

2.1 Redox (exothermic)✓ (1)

2.2 When a system in equilibrium is subjected to stress it shifts its equilibrium position in order to relieve the stress.✓✓ (2)

2.3.1 No effect ✓ (1)
2.3.2 Decrease✓ (1)
2.3.3 Increase✓ (1)

2.4 **Graph to show the distribution of molecular energies at constant temperature**



✓✓

- A **catalyst lowers the activation energy** required for an effective collision. ✓
- Since less kinetic energy is required for an effective collision **a greater percentage of the reacting particles will have the activation energy** needed to form products. Therefore the **reaction rate will be greater** because reaction rate is proportional to the number of effective collisions per second.✓

(4)

2.5 No change. A catalyst is not used up in the reaction.✓ (2)

2.6 Guano (bird & bat droppings)✓ (1)

2.7 42% of the box is fertiliser
% of nitrogen = $\frac{5}{15}$ ✓ of 42%✓
= 14%✓ (4)

2.8 Increased levels of nitrates & phosphates in the water that runs off farm land into dams & rivers causes **algal bloom** (rapid growth of water plants on the surface).✓ **Light is blocked** from plants beneath the surface which die and decay.✓ **Bacteria use up dissolved oxygen** in water ∴ other life forms (eg fish) die.✓

(3)

[20 marks]

Question 3 – Haber Process

3.1 $K_c = \frac{[NH_3]^2}{[N_2].[H_2]^3}$ ✓✓ (2)

3.2 $C = \frac{n}{V}$

$[N_2] = \frac{7}{10} = 0,7 \text{ mol.dm}^{-3}$ ✓

$[H_2] = \frac{8}{10} = 0,8 \text{ mol.dm}^{-3}$ ✓

$[NH_3] = \frac{2}{10} = 0,2 \text{ mol.dm}^{-3}$ ✓ (3)

3.3 $K_c = \frac{0,2^2}{0,7 \times 0,8^3}$ ✓

= **0,112**✓ (2)

3.4 Low yield ✓ (1)

3.5 Faster reaction rate ✓ (∴ products made faster & time costs money in industry). (1)

3.6 Hydrogen was added.✓ (1)

3.7 **Forward reaction favoured**✓ to use up excess H_2 ∴ $[N_2]$ & $[H_2]$ decreased & $[NH_3]$ increased.✓ (2)

3.8 **Decrease in temperature**✓. This would have **favoured** the **forward reaction**✓ to produce heat (exothermic) & relieve the stress ∴ $[N_2]$ & $[H_2]$ decreased & $[NH_3]$ increased.✓ This would have lead to an **increase in Kc**.✓ (4)

[16 marks]

Question 4 – Galvanic Cells

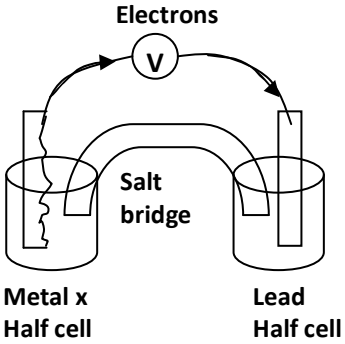
4.1.1 1 mol.dm^{-3} ✓ 25°✓ (2)

4.1.2 Anode✓ (1)

4.1.3 Lead Nitrate ✓ $Pb(NO_3)_2$ (1)

4.1.4 X ✓ (1)

4.1.5



- Electron direction✓
- Correct placement of half cells & salt bridge ✓
- Voltmeter & leads correctly placed.✓ (3)

4.1.6 Take a reading from the voltmeter ✓and substitute it as E°cell into the formula,
E°cell = E°cat – E°an✓
(Pb) (x)
$E°_x$ = -0,13✓ – E°cell
(voltmeter reading)
Compare the answer for $E°_x$ to values on SEP table to determine which metal it corresponds to. ✓
(4)

4.1.7 emf approaches zero.✓ (1)

4.1.8 emf increases✓ Forward reaction is favoured✓ because there are more Pb^{2+} ions to reduce ∴ electrons are transferred at a faster rate✓ (3)

[16]

4.2.1 Primary cell is not rechargeable. Secondary cell is rechargeable.✓
e.g. Lead-acid accumulator (car battery); nickel-cadmium battery.✓ (2)

4.2.2 Chemical (potential) to electrical.✓ (1)

4.2.3 Zinc is **<u>oxidised</u>** to Zn^{2+} ions ✓
$Zn \rightarrow Zn^{2+} + 2e^-$ ✓ (2)

4.2.4 It **<u>increases the surface area of the electrode</u>** ✓ (and lowers the internal resistance of the cell) ∴ more reactants in contact with the electrode ∴ **<u>faster reaction rate</u>** ✓∴ more electrons exchanged per second ∴ bigger current.✓ (3)

[8]

4.3.1 $Zn + 2MnO_2 \rightarrow ZnO + Mn_2O_3$✓✓ (-1 if not simplified) (2)

4.3.2 emf depends on the particular redox reaction which depends on the chemicals inside the cell, which are the same for both cells.✓✓ (2)

4.3.3 Cell capacity is the ability of the battery to deliver a specific amount of current in a specific amount of time.✓✓ (2)

4.3.4 The D type battery is bigger ✓ ∴ it contains more electrolyte (chemicals).✓ (2)

4.3.5 W = V x I x t ✓
= 1,5 x 0,8 x 3600✓
= **<u>4320 J</u>** ✓ (3)

4.3.6 Amp-hours needed = 0,6 x 4 = 2,4 A.h✓
<u>Zinc-carbon batteries</u> will need $\frac{2,4}{0,8}$ = **3** ✓ Cost = 3 x R5 = **R15**✓
<u>Alkaline battery</u> has a capacity of 2,8 A.h ∴ only need **one** Cost = **R9,50**✓
∴ cheaper to use one alkaline battery as opposed to 3 zinc-carbon batteries.✓ (5)

4.3.7 The **<u>reaction rate will be slower at lower temperatures</u>** ∴ chemicals not used up as quickly.✓✓ (2)

4.3.8
- Reduces waste that ends up in landfill sites (toxic chemicals)
- Reduces global warming since not replaced as often ∴less transportation of batteries to retail outlets etc.
- Reduces global warming since less energy used to manufacture them for same overall energy output as a rechargeable battery.
- Less destruction of forests to provide packaging.
- Less impact on air pollution (air acidification) because less of them are manufactured to produce the equivalent power of non-rechargeable batteries. **3 valid points** ✓✓✓(3) **[21]**

[**Q4 = 45 marks]**

Question 5 – Extraction of Aluminium

5.1
- Malleable ✓ - rolled into foil that's used for cooking.✓
- Excellent electrical conductor ✓- used in electrical wiring.✓
- Low density✓ - used in aeroplanes.✓
- Does not rust easily✓ - used in gutters, window frames, etc.✓

Any 2 (4)

5.2 To dissolve the $A\ell_2O_3$ at a lower temperature (950°C compared to 2000°C).✓ (1)

5.3 **Positive** – use less electricity ∴ less coal burned ∴ less CO_2 produced ∴ less global warming.✓
Negative – contains fluorine → toxic ∴ bad for environment.✓ (2)

5.4 $C + O_2 \rightarrow CO_2$ ✓
CO_2 is produced → greenhouse gas ∴ traps heat → global warming.✓ (2)

5.5 **Reasons to recycle**.
Uses 5% of electricity ∴….
- 95% saving of fossil fuels.
- 95% less greenhouse gas emissions.
- 95% less "red mud" dams → water contamination (NaOH)
- 95% less fluoride emissions → toxic
- Huge savings in daily running costs (95% less electricity)

Marking any 3 points = 2 marks each; any 4th point = 1 mark (7)

[16 marks]

Question 6 – Electrolysis of Sodium Chloride Solution

6.1 A, B, C ✓ (1)
6.2 Increasing the concentration of NaCℓ (aq) increases the rate of electrolysis.✓✓ (2)
6.3 B, D, E✓ (1)
6.4 The bigger the electrode the faster the rate of electrolysis.✓✓ (2)
6.5 B, F, G✓ (1)
6.6 As the distance between the electrodes decreases the rate of electrolysis increases.✓✓ (2)
6.7 There are **too many changing variables** which make it impossible to compare with any other experiment.✓✓ (2)

6.8 Electrical energy to chemical potential energy.✓ (1)

6.9 $2C\ell^- \rightarrow C\ell_2 + 2e^-$ ✓ (1)

6.10 $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ ✓ (1)

6.11 $2C\ell^- + 2H_2O \rightarrow C\ell_2 + H_2 + 2OH^-$ ✓ (1)
OR $2NaC\ell + 2H_2O \rightarrow 2NaOH + C\ell_2 + H_2$

6.12 E°cell = E°cat – E°an
= -0,83 – 1,36✓
= - **2,19V** ✓ **E°cell** n**egative** therefore non-spontaneous ✓ (3)

6.13
- It produces high purity NaOH which is separated from the brine.
- $C\ell_2$ can't react with NaOH to produce NaOCℓ.
- $H_2 + C\ell_2$ produced in different areas → prevents explosion if they meet and react.
- Hydroxide ions oxide at the anode in Siphiwe and David's apparatus. This will form oxygen gas which reacts with the graphite (carbon) anodes to form CO_2 ∴ anodes corrode.

(Any **2** relevant advantages)✓✓ (2)

6.14 Mercury poisoning → numbness of hands and feet, nerve damage; brain damage; foetal damage etc.✓ (1)

6.15 Asbestos poisoning → asbestosis; lung cancer.✓ (1)

6.16 They use less energy ∴lower operating costs.✓ (1)

6.17 Chlorine → kills bacteria in water✓ ∴ prevents 'me' getting diseases.✓
Sodium hydroxide → used to make soap✓ ∴ keeps 'me' clean.✓ (4)
Any **2** relevant uses

6.18 Opinion ✓
Justification ✓✓✓ (4)

Eg. **Opinion** -Advantages do not outweigh disadvantages✓

- It is unethical to overlook the 'poisoning' of a few workers so that the larger population can benefit from the use of the products.✓
- Whilst changing the cell technology may be expensive it would be better to increase the prices of the products in order to finance the new technology. Lives are more important than money.✓
- The chemicals produced are used to manufacture products that are essential to the health of a nation eg drugs, disinfectants, ammonia to make fertilisers which is needed for crop growth (food). However, cut-backs must be made somewhere else – people's lives can't be sacrificed no matter how valuable the products of the process.✓

[31 marks]

Total: 150 marks