1.

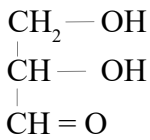
(a)

(i) It is a polyhydroxy ketone (a ketone with two hydroxyl groups)

(ii) Dihydroxyacetone has polar groups such as hydroxyls and carbonyl which are able to form hydrogen bonds with water. Dihydroxyacetone does not have any long non-polar chains so the hydrogen bonding is strong enough to allow its molecules to be separated and mixed with the water molecules.

(iii)

(1)



(2)

(A) Tollen's reagent (ammoniacal silver nitrate)

(B) A silver mirror forms

(b)

(i) Disaccharide

(ii)

(1) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

(2) Endothermic

2.

(a)

(i) Presence of alkene group(s)

(ii) $M_{C_5H_8} = 12.01 \times 5 + 1.008 \times 8 = 68.114 \text{ g mol}^{-1}$

$$\frac{750000}{68.114} = 11011 \text{ units}$$

(iii) Four

(iv) Thermoplastic

(v) Microorganisms or other living things are able to break the long backbone chains into smaller and smaller units.

(b) Producing rubber from plants allows more petroleum to be used for other applications. This is especially beneficial for applications where renewable alternatives are not yet viable.

(c)

(i) The cross-links connect chains of the polymer together by covalent bonds. These are strong bonds which cause the chains to not able to move as freely, so the rubber is less flexible.

(ii) The strong covalent cross-links mean more energy is required to separate the chains, so the rubber is difficult to melt or soften and reform.

3.

(a)

(i) 6.4

(ii) The amine group is more polar than the ketone group therefore 1-phenylpropan-2-amine is more polar than 1-phenylpropan-2-one. The stationary phase is non-polar so 1-phenylpropan-2-one will travel more slowly through the column and elute last. Therefore 1-phenylpropan-2-one is represented by peak B.

(b)

(i) The pH has likely been decreased, since there is a protonated amine group present.

(ii) Significantly altering the pH could change the interactions between chains so much that the spatial arrangement of the protein could be irreversibly altered.

(iii)

(1) The negatively charged proteins are found lower down the column because they are not adsorbed to the cation exchange surface (negatively charged beads of resin). The positively charged proteins are attracted to the resin and therefore move more slowly downwards through the column.

(2) Increasing the concentration of $Na^{+}_{(aq)}$ will cause a net reaction in the direction that opposes the change, in this case the forwards direction. The $Na^{+}_{(aq)}$ ions will be adsorbed to the cation exchange surface, displacing the $protein^{+}_{(resin)}$ ions that were there.

4.

(a)

(i) $m = n \times M = 1 \times 32.040 = 32.040$ g

$Q = \text{energy per gram} \times m = 22.7 \times 32.040 = 727$ kJ

(ii)

(1) $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O \quad \Delta H = -1345$ kJ mol^{-1}

(2) $\frac{\text{g}}{\text{L}} \div \frac{\text{g}}{\text{mol}} = \frac{\text{mol}}{\text{L}}$

$\therefore 789 \div 46.068 = 17.1$ mol L^{-1}

1 L ethanol so $n = 17.1$ mol

$Q = \Delta H \times n = 1345 \times 17.1 = 2.30 \times 10^4$ kJ $= 2.30 \times 10^7$ J

$Q = mc\Delta T$

$\therefore m = \frac{Q}{c\Delta T} = \frac{2.30 \times 10^7}{4.18 \times (100 - 20)} = 6.9 \times 10^4 \text{ g} = 69 \text{ L}$

(3) Not all of the heat released by the ethanol will be transferred to the water (some will be transferred to the surroundings)

(b) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

(c) One factor to consider is the pressure of the reaction vessel, as both of Reaction 1 and Reaction 2 involve gas reactants. Increasing pressure will increase the rate of reaction, since the frequency of collisions between reactant particles would be increased. This increases yield per time. In addition to this, increasing pressure would shift the equilibrium position of Reaction 1 to the right, increasing yield.
Another factor to consider is the temperature of the reaction. For both reactions, increasing temperature will increase frequency and productivity of collisions, therefore increasing rate of reaction and therefore yield per time. However, Reaction 2 involves bacteria which are likely to be killed by high temperatures, which limits the maximum temperature that can be used to increase rate. The temperature of Reaction 1 can also be changed in order to shift the equilibrium position and therefore yield.

5.

(a) It is reactive (easily oxidised)

(b)

(i) Crushing the ore increases the surface area available to reactants, therefore increasing rate of reaction.

(ii) (formula of any Fe, Mn or Ti oxide, fluoride, or sulphate, for example Fe_2O_3)

(iii) KF

(iv)

(1) Sodium is high on the metal reactivity series (easily oxidised) therefore readily gives its electrons (acting as a reducing agent). Tantalum must have a lower reactivity than sodium in order to be reduced by sodium in this way.

(2) $K_2TaF_7 + 5Na \rightarrow Ta + 5NaF + 2KF$

6.

(a)

(i) Reduce cloudiness of the water

(ii) Fine clay particles have a negative surface charge and are therefore attracted to the positive charge on each unit of the polyDADMAC chains. This causes the clay particles to flocculate into larger particles which are heavy enough to fall out of suspension.

(b)

(i) Eutrophication

(ii)

(1) This calcium ion has had one of its $3p^6$ electrons raised to the higher energy 4s subshell. The electron will returns to its original subshell by releasing energy in the form of light.

(2) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

(c)

(i) Reverse osmosis is the process of using high pressure to force the solution through a semi-permeable membrane. The membrane allows the water to pass through but not the dissolved salts. Therefore the dissolved salts will not be present in the output water.

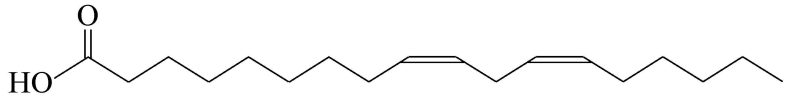
(ii) The salt concentration of nearby marine habitats could be increased and cause harm to organisms.

7.

(a) Alkene groups (C=C bonds)

(b)

(i) The alkene groups cause the hydrocarbon chains to bend, preventing the molecules from packing closely together. This causes the dispersion forces between molecules to be weaker, therefore not much energy is required to separate them to form a liquid.

(ii) 

(iii)

(1) $M_{KOH} = 39.10 + 16.00 + 1.008 = 56.108 \text{ g mol}^{-1}$

$m = nM \quad \text{and} \quad n = CV$

$\therefore m = CVM = 0.0250 \times 0.2500 \times 56.108 = 0.3507 \text{ g}$

(2)

(A) Volumetric pipette

(B) $n_{KOH} = CV = 0.0250 \times 0.02000 = 5.00 \times 10^{-4} \text{ mol}$

$\frac{n_{acid}}{n_{KOH}} = \frac{1}{1} \quad \{\text{from b(ii)}\}$

$\therefore n_{acid} = n_{KOH} = 5.00 \times 10^{-4} \text{ mol}$

$C = \frac{n}{V} = \frac{5.00 \times 10^{-4}}{0.00712} = 0.070 \text{ mol L}^{-1}$

(C) To reduce the effect of random error

8.

(a) Both the energy per volume and energy per mass are greater for Li-ion, meaning the consumer devices can be more portable since the batteries are lighter and take up less space.

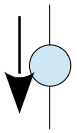
(b)

(i) $V^{2+} \rightarrow V^{3+} + e^-$

(ii) Oxidation

(c)

(i) It produces electrical energy

(ii) 

(iii) Operation of photovoltaic cells does not require the burning of fossil fuels which drives many steam turbines.
Burning fossil fuels increases carbon dioxide in the atmosphere. Therefore using photovoltaic cells have a lower contribution to the enhanced greenhouse effect than steam turbines burning fossil fuels.
Burning fossil fuels also produces pollutants such as nitrogen oxides which contribute to photochemical smog (and acid rain). Operation of photovoltaic cells does not release any pollutants.

9.

(a)

(i) $CO_2 + H_2O \rightarrow H_2CO_3$

(ii) Decreases

(iii) Increasing temperature causes less CO_2 to be dissolved in the water, which means there will be less to react with the water. Therefore increasing temperature will decrease concentration of H_2CO_3. This will increase the pH of the water, since less H_2CO_3 will be available to ionise to form H^+.

(b)

(i) $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + H_2O + CO_2$

(ii) Weakened

(iii) International collaboration and communication between scientists has been shown here by the sharing of information about the effectiveness of the new technologies. There are a large number of carbon capture and storage projects in operation around the world and if each of these worked in isolation they would make progress very slowly. Collaboration allows them to each benefit from the experience of the others.
The carbon capture technologies are industrial-scale and have been highly effective, meaning they can be confidently applied by the global community to reduce the contribution of carbon dioxide emissions to the enhanced greenhouse effect.