2.7 identify neutralisation as a proton transfer reaction which is exothermic
Neutralisation is a proton transfer reaction in which an acid and a base react to form a salt and water. Neutralisation reactions are exothermic. The amount of heat liberated when neutralisation occurs depends on on the strengths of the acid and the base.

- The amount of heat liberated per mole when a strong base is neutralised by a strong acid is almost the same no matter what acid or base is used.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l) \qquad \Delta H = -57.9 \text{ kJ/mol}$$
$$HNO_3(aq) + KOH(aq) \rightarrow KNO_3(aq) + H_2O(l) \qquad \Delta H = -57.3 \text{ kJ/mol}$$

- *Examples of 1 mol/L solutions:*

- The neutralisation reactions involving weak acids or bases, however, produce slightly less heat per mole.

$$CH_3COOH(aq) + NaOH(aq) \rightarrow NaCH_3COO(aq) + H_2O(l) \qquad \Delta H = -56.1 \text{ kJ/mol}$$

- *Example of a 1 mol/L solution:*

2.8 assess the use of neutralisation reactions as a safety measure or to minimise damage in accidents or chemical spills

In the laboratory:
Neutralisation reactions can be used in laboratories to clean up after acids or bases that have been accidentally spilled on the workbench or floor. Concentrated acids or bases should never be used to clean up spills due to the exothermic nature of the neutralisation process. They have the potential to cause boiling, the evolution of noxious fumes and will only cause further damage.

***When an acid is spilled on the bench or floor*:**
- The spill area must be isolated:
  - Room must be evacuated if fumes are present.
  - If the acid has been spilled on a person's clothes or skin, immediate first aid must be administered.
  - The skin or clothing must be flushed with copious amounts of water to prevent damage.
  - The contaminated clothing must be removed.

- The spill must be isolated:
  - This can be done with sand or **vermiculite** to prevent the acid flowing out to contaminate other areas.
  - The acid-soaked sand or vermiculite can then be cleaned up and neutralised in a safe location.

- The acid must be neutralised:
  - A concentrated acid spill should be diluted with water before the acid is neutralised with a base. This is because a great amount of heat is released during the neutralisation of a concentrated acid.
  - The acid can be neutralised using an excess of a powdered base such as sodium carbonate or sodium hydrogen carbonate. A strong base should not be used.
  - Sodium carbonate is commonly used as it is a stable solid that is safe to handle. It is also the cheapest of the bases commonly available.

$$Na_2CO_{3(s)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

  - Sodium hydrogen carbonate is also commonly used to clean up acid spills. It is a weak base that is non-toxic.

$$NaHCO_{3(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Larger-scale neutralisations:

If very large acid spills occur *(e.g. a tanker carrying acid crashes and the acid spills onto the road):*

- Add large amounts of inert sand or vermiculite to prevent the acid escaping into the drains or off into the soil on the side of the road.
- Once the acid is absorbed, the highly acidic sand or vermiculite can be placed in a chemical waste container and removed for neutralisation off-site.
- Once the acidic solid is removed, sodium carbonate powder followed by copious quantities of water are used to neutralise and dilute any remaining acid.

If an alkaline has been spilled:

- One option is to use sodium hydrogen carbonate, as it is amphiprotic. It can react with alkalis as well as acids and neutralise them.

$$NaHCO_{3(s)} + NaOH_{(aq)} \rightarrow Na_2CO_{3(aq)} + H_2O_{(l)}$$

- Sodium hydrogen phosphate solid is also used in base spills. It is also amphiprotic.
- In many factory situations, alkaline wastes can be carefully neutralised with dilute hydrochloric acid followed by large volumes of water.
- If the spillage of acids or bases occurs on a large scale in factories, it is important that once the acid or base has been neutralised, the products are diluted with copious quantities of water. This method prevents high concentrations of ions, or solutions with too high or too low a pH, from being discharged in the wastewater effluents.

Diluting strong acids safely:

Small quantities of the concentrated acid are added to a large volume of water with constant stirring. This process helps to dissipate the heat produced on dissolution.
The reverse procedure of adding water to the concentrated acid should not be attempted, as the hydration process causes such a large generation of heat that the acid's temperature can quickly rise to boiling point. There is a danger that boiling acid could be ejected from the beaker.