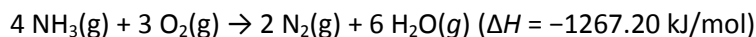
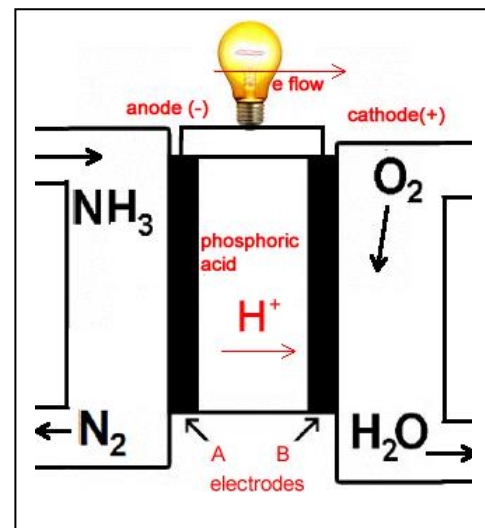


## Ammonia worksheet 5

1) Ammonia can be used as a fuel in fuel cells. The overall reaction is represented by the equation below.



Shown on the right is a phosphoric acid ammonia fuel cell.



- Write the equation to the reaction taking place at the cathode  
 $4\text{e}^- + 4\text{H}^+(\text{aq}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$
- Write the equation to the reaction taking place at the anode  
 $2\text{NH}_3 \rightarrow \text{N}_2(\text{g}) + 6\text{H}^+(\text{aq}) + 6\text{e}^-$
- Label the:
  - anode and cathode and give their polarity.
  - direction of electron flow
  - direction of positive ion movement

- The X-15, shown on the right, set a World speed record powered by ammonia and oxygen. A flow rate of 159 litres per second for anhydrous ammonia was achieved. Calculate the amount of energy in kJ that was produced every second if the density of anhydrous ammonia at 25°C and 1atm pressure is 0.683 g/L.



**Step 1 find the mass of ammonia**  
 $\Rightarrow \text{mass} = \text{density} \times \text{volume} = 159 \times 0.683 = 108.6 \text{ g}$   
**Step 2 find the mol of ammonia**  
 $\Rightarrow 108.6 / 17.0 = 6.39$   
**Step 3 find the energy given out.**  
 $\Rightarrow 1267.20 / 4 = x / 6.39$   
 $\Rightarrow \text{energy output} = 2023 \text{ kJ}$

2) The following are five reactions of ammonia that are used in industry.

- $\text{NH}_3(\text{g}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow (\text{NH}_4)_2\text{SO}_4(\text{aq})$  = Production of fertiliser
- $\text{NH}_3(\text{g}) + \text{HNO}_3(\text{aq}) \rightarrow \text{NH}_4\text{NO}_3(\text{aq})$  = Production of fertiliser and explosives
- $\text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \Rightarrow \text{NH}_4\text{OH}(\text{aq})$  → Cleaning agent
- $2\text{CH}_4(\text{g}) + 2\text{NH}_3(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{HCN}(\text{g}) + 6\text{H}_2\text{O}(\text{l})$  = Used in mining to extract gold
- $4 \text{NH}_3 + 3 \text{O}_2 \rightarrow 2 \text{N}_2 + 6 \text{H}_2\text{O}(\text{g})$  = energy source

- which of the above reactions show ammonia acting as a base? **a) b) c)**
- Which reactions are redox reactions? Explain **d) and e)**

in d) in  $\text{CH}_4$  carbon has an oxidation state of -4 and in  $\text{HCN}$  it has an oxidation state of +2. It is oxidised

Oxygen has a oxidation state of 0 in  $\text{O}_2$  and -2 in  $\text{H}_2\text{O}$  it is reduced.

In e) N has an oxidation state of -3 in  $\text{NH}_3$  and 0 in  $\text{N}_2$  it is oxidised. O in  $\text{O}_2$  has an oxidation state of 0 and an oxidation state of -2 in  $\text{H}_2\text{O}$  it is reduced.

3) Explain, using diagrams, why ammonia dissolves readily in ethanol but not in liquid alkanes such as butane.

Ethanol and ammonia both exhibit hydrogen bonding. Like dissolves like so both ethanol and ammonia molecules are capable of interacting with each other. Butane, however, does not have hydrogen bonding and hence little interaction occurs between liquid butane and ammonia. Amination of hydrocarbons usually takes place by dissolving the hydrocarbon and ammonia in ethanol.

