





1. Nitrogen and hydrogen gases can react, under certain conditions, to form gaseous ammonia, NH<sub>3</sub>. The reaction is reversible and can reach equilibrium.

(a) Balance the equation for this reaction and fill in the state symbols.



(b) Describe what is happening when this reaction is at equilibrium.

.....  
.....  
.....  
..... (2)

(c) About 80% of ammonia manufactured is used to make artificial fertilisers. Give an advantage and a disadvantage of using artificial fertilisers to grow food crops.

.....  
.....  
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..... (2)

(d) Ammonia is a simple molecular covalent substance. There are strong covalent bonds between the atoms in each molecule. Ammonia has a boiling point of -33°C. Explain why ammonia has a low boiling point.

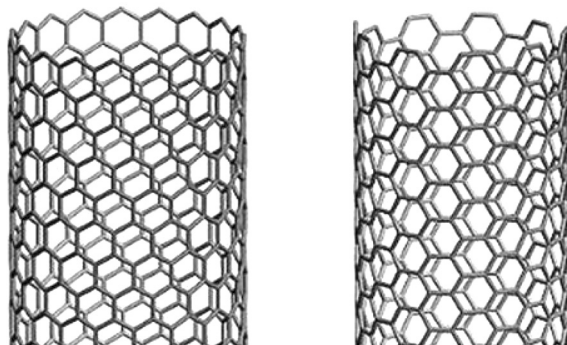
.....  
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..... (2)

(Total 8 marks)

Q1



2. Carbon nanotubes were discovered in the twentieth century. These long, thin cylinders of carbon atoms are giant structures. Each can be thought of as a graphite layer joined round to make a cylinder.



Their physical properties are still being discovered and disputed.

- (a) Carbon exists as two stable isotopes.

- (i) An atom of one of the carbon isotopes has an atomic number of 6 and a mass number of 13.

Complete the table to show the numbers of particles in this carbon atom.

particle	number of particles
electrons	
neutrons	
protons	

(2)

- (ii) How will the structure of an atom of the other carbon isotope differ from the structure of the atom described in (a)(i)?

.....  
 .....

(1)

- (b) Carbon nanotubes are five times stronger than steel and better electrical conductors than copper.

- (i) Suggest a possible use for carbon nanotubes.

.....  
 .....

(1)



(ii) Suggest why carbon nanotubes can conduct electricity.

.....

.....

.....

.....

(2)

(Total 6 marks)

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Q2



3. Poly(propene) is a thermoplastic.  
It is used to make car bumpers, washing-up bowls, chairs and ropes.



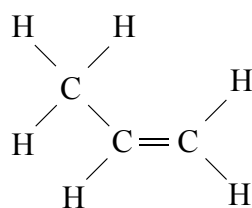
- (a) State the meaning of the term **thermoplastic**.

.....  
.....

(1)

- (b) Propene is the monomer used to make poly(propene).

The diagram shows the structure of a propene molecule.

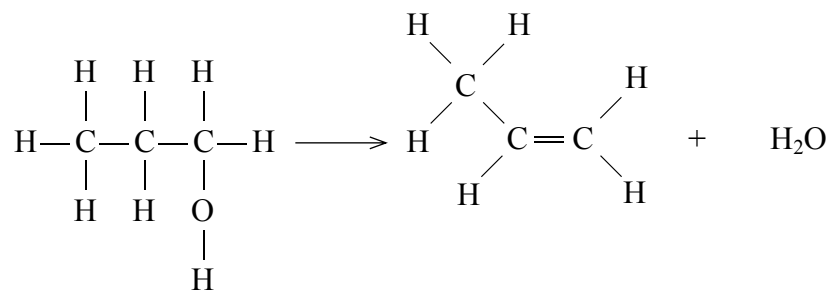


Draw a diagram to show the part of a poly(propene) chain formed from **two** propene monomer units.

(2)



(c) Propene can be produced by the dehydration of propanol.



propanol

- (i) Calculate the relative formula mass of propene.  
 (Relative atomic masses: H = 1.00, C = 12.0)

.....

answer = .....

**(1)**

- (ii) The relative formula mass of water is 18.

Use the equation

$$\text{atom economy} = \frac{\text{mass of required product}}{\text{total mass of products}} \times 100\%$$

to calculate the atom economy for the production of propene in this reaction.

.....

.....

atom economy = .....%

**(2)**

- (iii) Suggest why it is desirable for a reaction to have a high atom economy.

.....

.....

.....

**(1)**

**(Total 7 marks)**

**Q3**



4. Titanium is a hard metal with a relatively low density.  
Titanium and its compounds have a wide range of uses.

(a) In 1997, a new method to extract titanium was developed. Titanium was extracted by the electrolysis of titanium(IV) oxide,  $\text{TiO}_2$ , dissolved in molten calcium chloride. The molten electrolyte contains the titanium ions,  $\text{Ti}^{4+}$ .

(i) At which electrode is titanium deposited?

.....  
(1)

(ii) Why is it important that the temperature is high enough for the electrolyte to be molten?

.....  
.....  
(1)

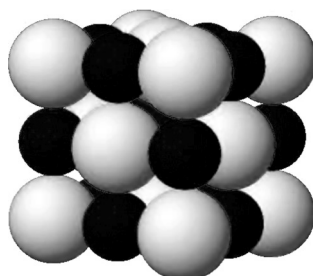
(iii) Write the half equation for the formation of titanium at the electrode.

.....  
(2)



(b) Read the following about titanium carbide.

Titanium carbide is an extremely hard ceramic material. It is used to make tool bits and cutting tools. It has the same structure as sodium chloride and has a melting point of 3140°C.



(i) 5.00 g of titanium carbide contains 1.00 g of carbon.  
Calculate the empirical formula of titanium carbide.  
(Relative atomic masses: C = 12.0, Ti = 48.0)

.....  
.....  
.....  
.....

empirical formula = .....  
**(3)**

(ii) Explain why titanium carbide has a high melting point.

.....  
.....  
.....

**(2)**

**Q4**

**(Total 9 marks)**

**TOTAL FOR PAPER: 30 MARKS**

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