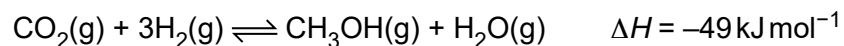


1 Methanol, CH₃OH, is an important feedstock for the chemical industry.

In the manufacture of methanol, carbon dioxide and hydrogen are reacted together in the reversible reaction shown below.



(a) Describe and explain the effect of increasing the pressure on the reaction **rate**.

.....
.....
..... [2]

(b) State le Chatelier's principle.

.....
.....
..... [1]

(c) High pressures and low temperatures would give a maximum equilibrium yield of methanol.

(i) Explain this statement in terms of le Chatelier's principle.

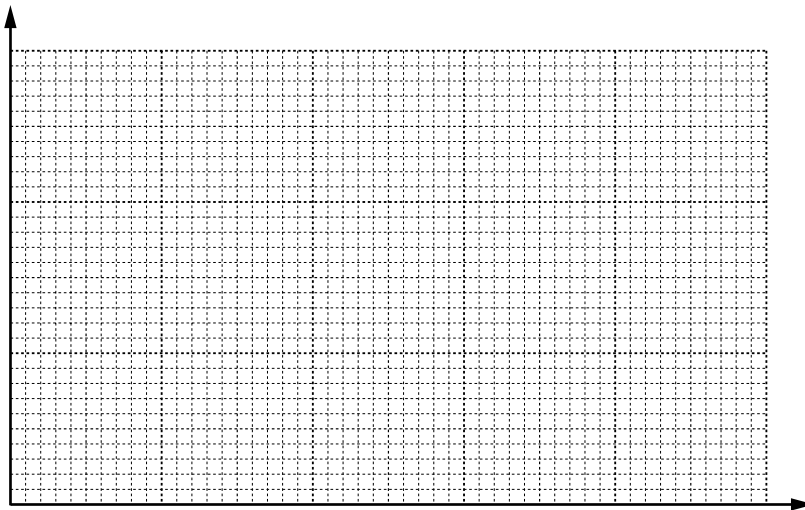
.....
.....
.....
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.....
.....
..... [3]

(ii) Explain why the actual conditions used by the chemical industry might be different.

.....
.....
.....
..... [2]

(d) The manufacture of methanol uses a catalyst.

- Sketch a labelled diagram of the Boltzmann distribution on the grid provided.
- Label your axes.
- Using your Boltzmann distribution, explain how the catalyst increases the rate of reaction.



.....
.....
.....
.....
..... [4]

(e) Explain why the use of a catalyst can reduce the demand for energy.

.....
.....
..... [1]

[Total: 13]

2 (a) Reaction rates can be increased or decreased by changing conditions of temperature and pressure.

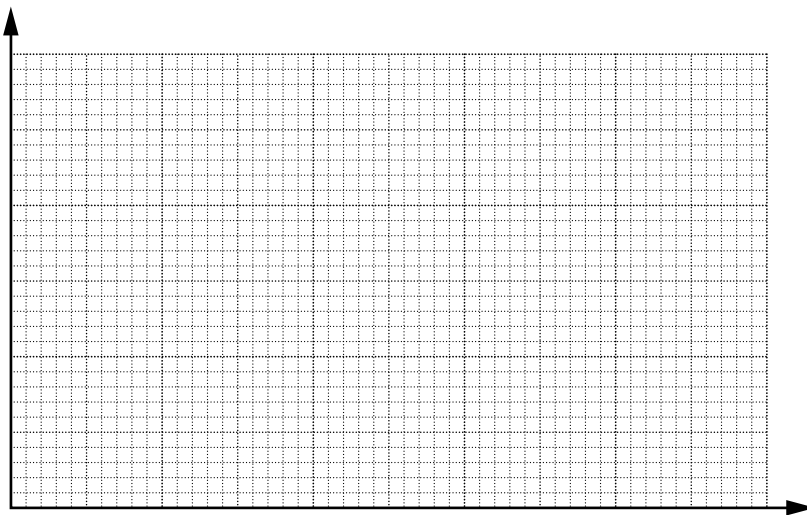
(i) Explain how increasing the temperature increases the rate of reaction.

Include a labelled sketch of the Boltzmann distribution, on the grid below.

Label the axes.



Your answer needs to be clear and well organised using the correct terminology.



.....

.....

.....

.....

.....

.....

.....

[4]

(ii) Describe and explain the effect of decreasing the pressure on the rate of a reaction.

.....
.....
.....
.....
..... [2]

(b) Catalysts are used to speed up chemical reactions.

(i) Write an equation for an industrial preparation of ethanol which involves the use of an enzyme in yeast.

State a suitable temperature for this reaction and **one** other essential condition.

equation

temperature °C.

condition

[2]

(ii) Catalytic converters are used to decrease the emission of nitrogen monoxide and carbon monoxide from the internal combustion engine. These two gases react together on the surface of the catalyst.

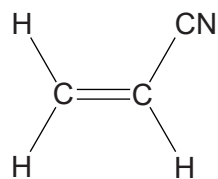
Write an equation for this reaction.

..... [1]

[Total: 9]

3 Poly(propenenitrile) is used to make acrylic fibres for clothing.

Poly(propenenitrile) is a polymer manufactured from propenenitrile.



propenenitrile

(a) Draw a section showing **two** repeat units of poly(propenenitrile).

[1]

(b) Explain why this manufacture of poly(propenenitrile) has a 100% atom economy.

.....
..... [1]

(d) A factory is able to make 11.13 kg of propenenitrile from 220 mol of propene.

Calculate the percentage yield of the reaction to form propenenitrile from propene.

percentage yield = % [2]

(e) The chemical industry uses temperature and catalysts to control the rate of reactions.

Using Boltzmann distribution diagrams, explain the effect on the rate of a reaction of:

- increasing the temperature
- adding a catalyst.

.....

.....

.....

.....

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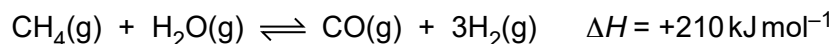
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4 Hydrogen has many industrial uses including making margarine and ammonia.

Hydrogen can be made by the reaction between methane and steam.



(a) The pressure of the equilibrium mixture is **increased**.

Explain what happens to the position of the equilibrium.

.....
.....
..... [2]

(b) The temperature of the equilibrium mixture is **increased**.

Explain what happens to the position of the equilibrium.

.....
.....
..... [2]

(c) The reaction is actually carried out in the presence of a nickel catalyst at a pressure of 30 atmospheres.

(i) Suggest why the manufacturer uses a pressure of 30 atmospheres.

.....
.....
..... [1]

(ii) The nickel catalyst increases the rate.

Use a labelled diagram of the Boltzmann distribution of molecular energies to explain why.

.....

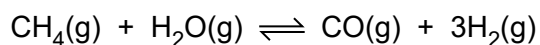
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..... [3]

(d) A chemical factory uses 200 tonnes of methane a day. The factory produces 68.4 tonnes of hydrogen per day by reacting methane with steam.

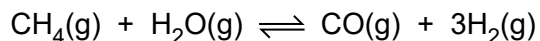


Calculate the percentage yield of hydrogen.

Give your answer to **three** significant figures. (1 tonne = 1×10^6 g)

percentage yield of hydrogen = % [3]

- (e) The carbon monoxide produced in the equation below can be reacted with hydrogen to make methanol.



- (i) Construct the equation for the reaction of carbon monoxide with hydrogen to make methanol.

..... [1]

- (ii) Suggest **two** reasons why it is important to use the carbon monoxide to make methanol.

.....

.....

.....

..... [2]

- (f) Describe how hydrogen can be used in the manufacture of margarine.

.....

.....

.....

..... [2]

[Total: 16]

5 Petrol and diesel are both complex mixtures of hydrocarbons used as fuels in transport.

- (a) Petrol contains some branched chain alkanes.
The number of carbon atoms per molecule varies between five and nine.

Name one branched chain alkane with between five and nine carbon atoms.

..... [1]

- (b) When petrol burns in an internal combustion engine the exhaust gases contain CO_2 , CO , NO , N_2 , O_2 , H_2O and unburnt hydrocarbons.

- (i) What effect does the absorption of infrared radiation have on the bonds in CO_2 molecules in the atmosphere?

..... [1]

- (ii) Why is CO present in the exhaust gases?

.....
..... [1]

- (iii) Both NO and CO are atmospheric pollutants.

For each pollutant, describe one environmental problem.

NO
.....
 CO
..... [2]

- (c) Most cars are fitted with a catalytic converter which catalyses the exothermic reaction between NO and CO to form two less harmful gases.

- (i) Name the two gases formed and write an equation for this reaction.

.....
.....
..... [2]

- (ii) NO and CO react very slowly without a catalyst.
The catalyst in a catalytic converter increases the rate of reaction.

Explain, using an enthalpy profile diagram and the Boltzmann distribution model, how the use of a catalyst increases the rate of reaction.

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.....

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..... [7]

