Chemical Reactions – 2023 June IGCSE Chemistry 0620

1. June/2023/Paper_ 0620/11/No.12

Lumps of calcium carbonate react with dilute hydrochloric acid as shown.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Which change in conditions decreases the rate of the reaction?

A increasing the concentration of the acid

B increasing the volume of the acid

C increasing the size of the lumps of calcium carbonate

D increasing the temperature

2. June/2023/Paper_ 0620/11/No.13

Solid copper(II) sulfate exists in two different forms, anhydrous and hydrated.

One of these forms is blue and the other is white.

The change between these two forms is reversible.

$$\text{blue form} \rightleftharpoons \text{white form}$$

What is the blue form and how is the change from the blue form to the white form brought about?

	blue form	change to white form
A	anhydrous	add water
B	anhydrous	heat
C	hydrated	add water
D	hydrated	heat

3. June/2023/Paper_ 0620/11/No.14

Four redox equations and statements about the equations are shown.

	reaction	statement
1	$C + O_2 \rightarrow CO_2$	carbon is oxidised
2	$CO_2 + C \rightarrow 2CO$	carbon dioxide is oxidised
3	$CO_2 + C \rightarrow 2CO$	carbon is oxidised
4	$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$	iron(III) oxide is oxidised

Which statements about the equations are correct?

A 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

4. June/2023/Paper_ 0620/12/No.12

Which changes increase the rate of reaction?

1 increasing the concentration of the reactants

2 increasing the particle size of a solid reactant

3 increasing the temperature

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

5. June/2023/Paper_ 0620/12/No.13

Which reaction is reversible?

A an iron nail rusting when left in moist air

B limestone reacting with an acid to form carbon dioxide gas

C magnesium burning in air to produce a white ash

D white anhydrous copper(II) sulfate turning blue when water is added

6. June/2023/Paper_ 0620/12/No.14

The equation for the reaction between iron(III) oxide and carbon is shown.

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

Which type of reaction does iron(III) oxide undergo?

A reduction

B precipitation

C oxidation

D combustion

7. June/2023/Paper_ 0620/13/No.12

Which row shows the changes that **all** increase the rate of a chemical reaction?

	concentration of reactants	temperature	particle size
A	decrease	decrease	decrease
B	decrease	increase	increase
C	increase	decrease	increase
D	increase	increase	decrease

8. June/2023/Paper_ 0620/13/No.13

A student heats hydrated copper(II) sulfate. The blue crystals change to a white powder.

How can the student reverse this reaction?

A Add anhydrous copper(II) sulfate to the white powder.

B Add water to the white powder.

C Cool the white powder.

D Reheat the white powder.

9. June/2023/Paper_ 0620/13/No.14

Acidified aqueous potassium manganate(VII) is a purple solution.

What does the (VII) in the name potassium manganate(VII) represent?

A the charge on the potassium ion

B the charge of the manganate ion

C the number of ions in the compound

D the oxidation number of manganese

10. June/2023/Paper_ 0620/21/No.12

Which row describes the effect on the activation energy and the frequency of particle collisions when the temperature of a chemical reaction is increased?

	activation energy	frequency of collisions
A	increases	increases
B	no change	increases
C	increases	no change
D	no change	no change

11. June/2023/Paper_ 0620/21/No.13

Solid copper(II) sulfate exists in two different forms, anhydrous and hydrated.

One of these forms is blue and the other is white.

The change between these two forms is reversible.

$$\text{blue form} \rightleftharpoons \text{white form}$$

What is the blue form and how is the change from the blue form to the white form brought about?

	blue form	change to white form
A	anhydrous	add water
B	anhydrous	heat
C	hydrated	add water
D	hydrated	heat

12. June/2023/Paper_ 0620/21/No.14

Sodium ions, Na^+, and oxygen ions, O^{2-}, combine with chromium ions to form a salt.

The salt sodium dichromate has the formula $Na_2Cr_2O_7$.

What is the oxidation state of chromium in this salt?

A +2 **B** +3 **C** +6 **D** +12

13. June/2023/Paper_ 0620/22/No.6

Which equation represents a chemical change?

A $BaCl_2(s) \rightarrow BaCl_2(l)$

B $Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$

C $KCl(s) + H_2O(l) \rightarrow K^+(aq) + Cl^-(aq)$

D $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(aq)$

14. June/2023/Paper_ 0620/22/No.12

Which change increases the rate of reaction by decreasing the activation energy, E_a?

A addition of a catalyst

B decrease in size of solid reactants

C increase in concentration of solutions

D increase in temperature

15. June/2023/Paper_ 0620/22/No.13

In the Contact process, sulfur dioxide is reacted with oxygen to form sulfur trioxide.

Which conditions are used in this reaction?

	temperature /°C	pressure /kPa	catalyst
A	300	200	iron
B	300	20 000	vanadium(V) oxide
C	450	200	vanadium(V) oxide
D	450	20 000	iron

16. June/2023/Paper_ 0620/22/No.14

Which reaction is reversible?

A an iron nail rusting when left in moist air

B limestone reacting with an acid to form carbon dioxide gas

C magnesium burning in air to produce a white ash

D white anhydrous copper(II) sulfate turning blue when water is added

17. June/2023/Paper_ 0620/22/No.15

The equation for the reaction of sulfur dioxide with acidified potassium dichromate(VI) is shown.

$$3SO_2 + Cr_2O_7^{2-} + 2H^+ \rightarrow 3SO_4^{2-} + 2Cr^{3+} + H_2O$$

What is oxidised and what is the oxidising agent?

	oxidised	oxidising agent
A	SO_2	$Cr_2O_7^{2-}$
B	SO_2	H^+
C	$Cr_2O_7^{2-}$	H^+
D	$Cr_2O_7^{2-}$	$Cr_2O_7^{2-}$

18. June/2023/Paper_ 0620/23/No.14

Magnesium reacts with hydrochloric acid to form magnesium chloride and hydrogen.

Why does magnesium powder react faster than magnesium ribbon?

A The magnesium atoms in the powder have a lower activation energy.

B The powder has a smaller surface area.

C The magnesium atoms in the powder have more frequent collisions with acid particles.

D The magnesium atoms in the powder have greater kinetic energy.

19. June/2023/Paper_ 0620/23/No.15

Which row shows the conditions used in the Contact process?

	catalyst	pressure / atm	temperature / °C
A	iron	2	100
B	iron	200	450
C	vanadium(V) oxide	2	450
D	vanadium(V) oxide	200	100

20. June/2023/Paper_ 0620/23/No.16

A student heats hydrated copper(II) sulfate. The blue crystals change to a white powder.

How can the student reverse this reaction?

A Add anhydrous copper(II) sulfate to the white powder.

B Add water to the white powder.

C Cool the white powder.

D Reheat the white powder.

21. June/2023/Paper_ 0620/23/No.17

Which reaction of hydrochloric acid is a redox reaction?

A $MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$

B $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

C $MgO + 2HCl \rightarrow MgCl_2 + H_2O$

D $Mg + 2HCl \rightarrow MgCl_2 + H_2$

22. June/2023/Paper_ 0620/31/No.6(a)

(a) A student investigates the reaction of small pieces of zinc of the same mass and size with three different concentrations of dilute hydrochloric acid in the presence of a catalyst.

The three concentrations of dilute hydrochloric acid are:

- 1.0 mol / dm^3
- 1.5 mol / dm^3
- 2.0 mol / dm^3.

All other conditions stay the same.

Table 6.1 shows the time taken for each reaction to finish.

Table 6.1

concentration of hydrochloric acid in mol / dm^3	time taken for the reaction to finish in s
	200
	100
	150

(i) Complete Table 6.1 by writing the concentrations of hydrochloric acid in the first column. [1]

(ii) Describe the effect on the time taken for the zinc to finish reacting with 2.0 mol / dm^3 hydrochloric acid with no catalyst present.

All other conditions stay the same.

..... [1]

(iii) Describe the effect on the time taken for the zinc to finish reacting with 2.0 mol / dm^3 hydrochloric acid when the surface area of the zinc is increased.

All other conditions stay the same.

..... [1]

23. June/2023/Paper_ 0620/32/No.6(a)

(a) A student investigates the reaction of different-sized pieces of calcium carbonate with dilute hydrochloric acid.

The sizes of the pieces of calcium carbonate are:

- large
- medium
- small.

All other conditions stay the same.

Table 6.1 shows the time taken for each reaction to finish.

Table 6.1

size of pieces of calcium carbonate	time taken for the reaction to finish / s
	160
	50
	450

(i) Complete Table 6.1 by writing the sizes of the pieces of calcium carbonate in the first column. [1]

(ii) Describe the effect on the time taken for small pieces of calcium carbonate to finish reacting with dilute hydrochloric acid when the temperature is increased.

All other conditions stay the same.

..... [1]

(iii) Describe the effect on the time taken for small pieces of calcium carbonate to finish reacting with dilute hydrochloric acid when the concentration of hydrochloric acid is decreased.

All other conditions stay the same.

..... [1]

24. June/2023/Paper_ 0620/33/No.6(a)

(a) A student investigates the reaction of magnesium with dilute hydrochloric acid at three different temperatures.

The temperatures are:

- 20 °C
- 30 °C
- 40 °C.

All other conditions stay the same.

Table 6.1 shows the time taken for each reaction to finish.

Table 6.1

temperature /°C	time taken for the reaction to finish/s
	45
	210
	95

(i) Complete Table 6.1 by writing the temperatures in the first column. [1]

(ii) Describe the effect on the time taken for the magnesium to finish reacting with dilute hydrochloric acid when the surface area of the magnesium is increased.

All other conditions stay the same.

..... [1]

(iii) Describe the effect on the time taken for the magnesium to finish reacting with dilute hydrochloric acid when the concentration of acid is decreased.

All other conditions stay the same.

..... [1]

25. June/2023/Paper_ 0620/41/No.4

Oxygen is produced by the decomposition of aqueous hydrogen peroxide. Manganese(IV) oxide, MnO_2, is a catalyst for this reaction.

(a) State the meaning of the term catalyst.

.....

..... [2]

(b) A student adds powdered manganese(IV) oxide to aqueous hydrogen peroxide in a conical flask as shown in Fig. 4.1. The mass of the conical flask and its contents is measured at regular time intervals. The mass decreases as time increases.

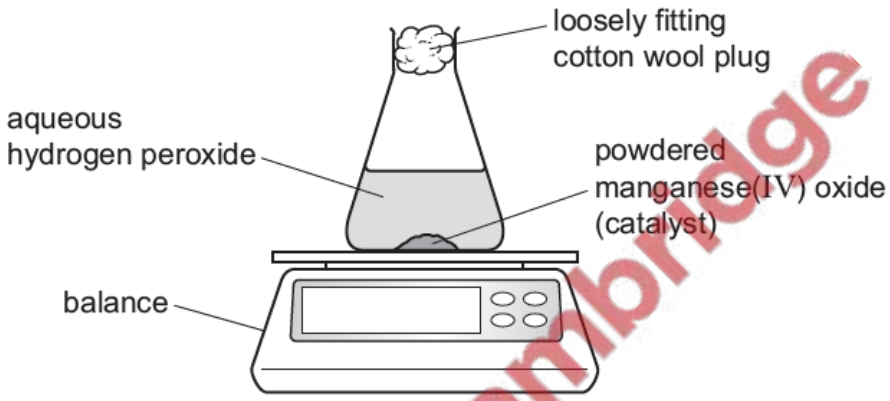


Fig. 4.1

(i) State why the mass of the conical flask and its contents decreases as time increases.

..... [1]

(ii) The rate of reaction is highest at the start of the reaction. The rate decreases and eventually becomes zero.

Explain why the rate of reaction is highest at the start of the reaction.

.....

..... [1]

(iii) Explain why the rate of reaction eventually becomes zero.

.....

..... [1]

(c) The experiment is repeated at an increased temperature.
All other conditions stay the same.

Explain in terms of collision theory why the rate of reaction is higher at an increased temperature.

.....

.....

.....

..... [3]

(d) The equation for the decomposition of aqueous hydrogen peroxide, $H_2O_2(aq)$, is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

50.0 cm^3 of a 0.200 mol/dm^3 solution of $H_2O_2(aq)$ is used.

Calculate the mass of O_2 that forms.
Use the following steps.

- Calculate the number of moles of H_2O_2 used.

..... mol

- Determine the number of moles of O_2 produced.

..... mol

- Calculate the mass of O_2 produced.

..... g
[3]

(e) State the effect on the mass of oxygen produced if the mass of powdered manganese(IV) oxide catalyst is increased.

..... [1]

(f) Oxygen can also be produced by the decomposition of mercury(II) oxide, HgO.
The only products of this decomposition are mercury and oxygen.

Write a symbol equation for this decomposition.

..... [2]

[Total: 14]

26. June/2023/Paper_ 0620/41/No.6

This question is about sulfur and compounds of sulfur.

Sulfur is converted into sulfuric acid, H_2SO_4, by the Contact process.

The process involves four stages.

stage 1 Molten sulfur is converted into sulfur dioxide.

stage 2 Sulfur dioxide reacts with oxygen to form sulfur trioxide.

stage 3 Sulfur trioxide combines with concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

stage 4 Oleum reacts to form concentrated sulfuric acid.

(a) (i) In **stage 1**, iron pyrites, FeS_2, can be used instead of molten sulfur.
The iron pyrites is heated strongly in air.

Balance the equation for the reaction occurring when iron pyrites reacts with oxygen in the air.

$$.....FeS_2 + ...O_2 \rightarrow .....Fe_2O_3 + ...SO_2$$ [1]

(ii) Name Fe_2O_3. Include the oxidation number of iron.

..... [1]

(b) The equation for **stage 2** is shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The forward reaction is exothermic.
The reaction is carried out at a temperature of 450 °C and a pressure of 2 atm.

Using explanations that do **not** involve cost:

(i) explain why a temperature greater than 450 °C is **not** used

.....

..... [1]

(ii) explain why a pressure lower than 2 atm is **not** used.

.....

..... [1]

(c) When sulfuric acid reacts with ammonia the salt produced is ammonium sulfate.

Write the symbol equation for this reaction.

..... [2]

(d) Lead(II) sulfate is an insoluble salt.

Lead(II) sulfate can be made from aqueous ammonium sulfate using a precipitation reaction.

(i) Name a solution that can be added to aqueous ammonium sulfate to produce a precipitate of lead(II) sulfate.

..... [1]

(ii) Write an ionic equation for this precipitation reaction. Include state symbols.

..... [3]

(iii) The precipitate of lead(II) sulfate forms in an aqueous solution.

Describe how pure lead(II) sulfate can be obtained from the mixture.

.....

.....

..... [3]

[Total: 13]

27. June/2023/Paper_ 0620/42/No.3

Over 200 million tonnes of sulfuric acid are manufactured every year.

(a) State the name of the process used to manufacture sulfuric acid.

..... [1]

(b) Part of the manufacture of sulfuric acid involves converting sulfur dioxide to sulfur trioxide.

(i) Describe **two** methods by which sulfur dioxide is obtained.

1 .....

2 .....

[2]

The conversion of sulfur dioxide to sulfur trioxide is a reversible reaction which can reach equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(ii) State **two** features of an equilibrium.

1 .....

2 .....

[2]

(iii) State the typical conditions and name the catalyst used in the conversion of sulfur dioxide to sulfur trioxide.

temperature ..... °C

pressure ..... kPa

catalyst .....

[3]

(iv) Complete Table 3.1 to show the effect, if any, when the following changes are applied to the conversion of sulfur dioxide to sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The forward reaction is exothermic.

Only use the words **increases**, **decreases** or **no change**.

Table 3.1

change	effect on the rate of the forward reaction	effect on the concentration of $SO_3(g)$ at equilibrium
temperature decreases	decreases	
pressure increases		
no catalyst	decreases	

[4]

(v) Explain in terms of collision theory why reducing the temperature decreases the rate of the forward reaction.

.....

.....

.....

.....

..... [3]

(c) Sulfuric acid contains SO_4^{2-} ions.

The oxidation number of O atoms in SO_4^{2-} ions is –2.

Determine the oxidation number of S atoms in SO_4^{2-} ions. Show your working.

oxidation number = ... [2]

[Total: 17]

28. June/2023/Paper_ 0620/43/No.4(a, b)

Hydrogen is produced by the reaction between zinc and dilute sulfuric acid, H_2SO_4.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

(a) A student carries out an experiment using excess zinc and dilute sulfuric acid.

The student measures the volume of hydrogen produced at regular time intervals using the apparatus shown in Fig. 4.1.

Lumps of zinc are used.

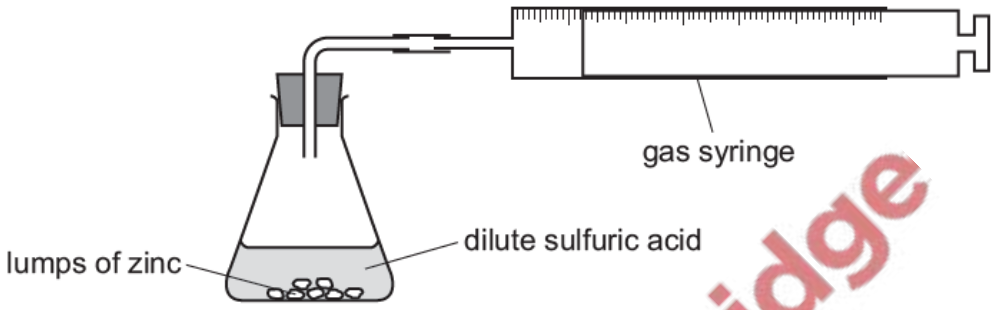


Fig. 4.1

The rate of reaction decreases as the reaction progresses. The rate eventually becomes zero.

(i) Explain why the rate of reaction decreases as the reaction progresses.

.....

..... [1]

(ii) Explain why the rate of reaction eventually becomes zero.

.....

..... [1]

(b) The experiment is repeated using powdered zinc instead of lumps of zinc.
All other conditions remain the same.

Explain, in terms of collision theory, why the rate of reaction increases if powdered zinc is used.

.....

.....

..... [2]

29. June/2023/Paper_ 0620/43/No.6

This question is about nitrogen and compounds of nitrogen.

(a) Ammonia is manufactured by the reaction between nitrogen and hydrogen in the Haber process.
The equation is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) State the source of nitrogen for the Haber process.

..... [1]

(ii) State the source of hydrogen for the Haber process.

..... [1]

(iii) State the typical conditions used in the Haber process.

temperature ..... °C

pressure ..... atm

[2]

(iv) Name the catalyst used in the Haber process.

..... [1]

(v) State what is meant by the term catalyst.

.....

..... [2]

(b) Ammonia is converted into nitric acid.

(i) The first stage is the conversion of ammonia into nitrogen monoxide, NO.
The equation is shown.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

The reaction is carried out at a temperature of 900 °C and a pressure of 7 atm.
The forward reaction is exothermic.

Using explanations that do **not** involve cost:

- explain why a temperature less than 900 °C is **not** used

.....

- explain why a pressure greater than 7 atm is **not** used.

.....
[2]

(ii) In the second stage, nitrogen monoxide reacts with water and oxygen to produce nitric acid.

Balance the symbol equation for the reaction.

$$.....NO + ...O_2 + ...H_2O \rightarrow .....HNO_3$$ [1]

(c) A student makes aqueous copper(II) nitrate by adding an excess of solid copper(II) carbonate to dilute nitric acid.

(i) Write the symbol equation for this reaction.

..... [2]

(ii) State **two** observations that indicate the copper(II) carbonate is in excess.

1 .....

2 .....
[2]

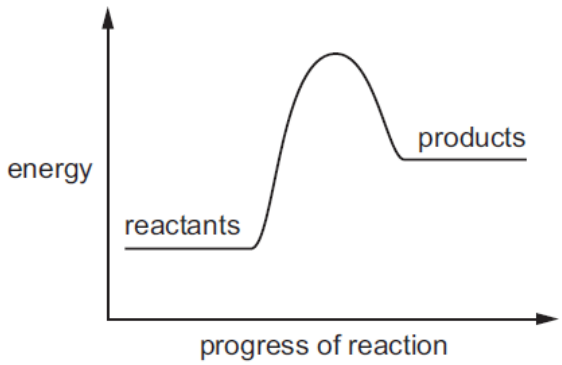
(iii) Name **one** compound, other than copper(II) carbonate, that can be added to dilute nitric acid to produce aqueous copper(II) nitrate.

..... [1]

[Total: 15]

30. March/2023/Paper_ 0620/12/No.12

The reaction pathway diagram for a reaction is shown.



Which statements about the reaction are correct?

1 The reaction is endothermic.

2 The reaction is exothermic.

3 The diagram represents the combustion of methane.

4 The diagram represents the thermal decomposition of limestone.

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

31. March/2023/Paper_ 0620/12/No.13

Which row describes a chemical change?

	new substances are made	there is a change of state
A	always	always
B	always	sometimes
C	never	always
D	never	sometimes

32. March/2023/Paper_ 0620/12/No.14

Magnesium powder reacts with an excess of dilute hydrochloric acid to produce hydrogen gas.

Which statements about this reaction are correct?

1 The smaller the particles of magnesium powder, the more slowly the hydrogen is produced.

2 The higher the temperature, the faster the magnesium powder disappears.

3 The lower the concentration of dilute hydrochloric acid, the faster the rate of reaction.

4 The faster the magnesium powder disappears, the faster the rate of reaction.

A 1 and 2 **B** 2 and 3 **C** 2 and 4 **D** 3 and 4

33. March/2023/Paper_ 0620/12/No.15

Which statement about hydrated cobalt(II) chloride is correct?

A It turns blue when it is heated.

B It turns blue when water is added to it.

C It turns pink when water is added to it.

D It turns white when it is heated.

34. March/2023/Paper_ 0620/22/No13

Magnesium powder reacts with an excess of dilute hydrochloric acid to produce hydrogen gas.

Which statements about this reaction are correct?

1 The smaller the particles of magnesium powder, the more slowly the hydrogen is produced.

2 The higher the temperature, the faster the magnesium powder disappears.

3 The lower the concentration of dilute hydrochloric acid, the faster the rate of reaction.

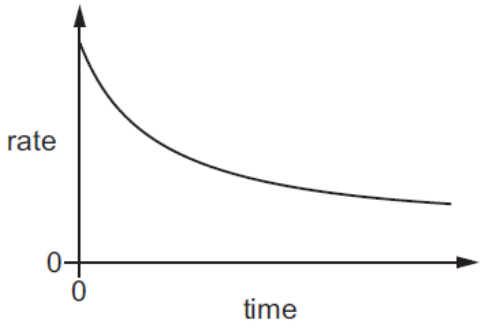
4 The faster the magnesium powder disappears, the faster the rate of reaction.

A 1 and 2 **B** 2 and 3 **C** 2 and 4 **D** 3 and 4

35. March/2023/Paper_ 0620/22/No14

The reaction between two aqueous compounds, X and Y, is slow and exothermic.

The graph shows how the rate of this reaction changes with time.



A student suggests that the rate of reaction decreases with time because:

1 the activation energy decreases

2 the speed of the molecules of X and Y decreases

3 the concentration of both X and Y decreases with time.

Which suggestions are correct?

A 1 and 2 **B** 1 and 3 **C** 2 only **D** 3 only

36. March/2023/Paper_ 0620/22/No15

Hydrogen reacts with iodine to form hydrogen iodide.

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

Which statements explain why the reaction is faster when the pressure is increased, at constant temperature?

1 At higher pressure, the molecules are moving faster.

2 At higher pressure, more of the molecules have the required activation energy.

3 At higher pressure, the molecules are closer together.

4 At higher pressure, the molecules collide more frequently.

A 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

37. March/2023/Paper_ 0620/22/No16

Ammonium sulfate is used as a fertiliser.

It is made from ammonia and sulfuric acid.

The .....1..... is made by the .....2..... process in which .....3..... is used as a catalyst.

Which words complete gaps 1, 2 and 3?

	1	2	3
A	ammonia	Contact	iron
B	ammonia	Haber	vanadium(V) oxide
C	sulfuric acid	Contact	vanadium(V) oxide
D	sulfuric acid	Haber	iron

38. March/2023/Paper_ 0620/22/No17

The reversible reaction shown takes place in a closed system at constant temperature.

$$P(g) + Q(g) + R(g) \rightleftharpoons S(g) + T(g)$$

When the reaction has reached equilibrium, more T is added.

After the addition of T, which other substances increase in concentration?

A P, Q, R and S

B P and Q only

C P, Q and R only

D S only

39. March/2023/Paper_ 0620/22/No18

In which equation is the underlined substance acting as a reducing agent?

A $3\underline{CO} + Fe_2O_3 \rightarrow 2Fe + 3CO_2$

B $\underline{CO_2} + C \rightarrow 2CO$

C $\underline{CuO} + H_2 \rightarrow Cu + H_2O$

D $\underline{CaO} + H_2O \rightarrow Ca(OH)_2$

40. March/2023/Paper_ 0620/32/No.8

A student investigates the reaction of iron powder with dilute hydrochloric acid at 20 °C. The hydrochloric acid is in excess.

(a) Fig. 8.1 shows the volume of hydrogen gas released as the reaction proceeds.

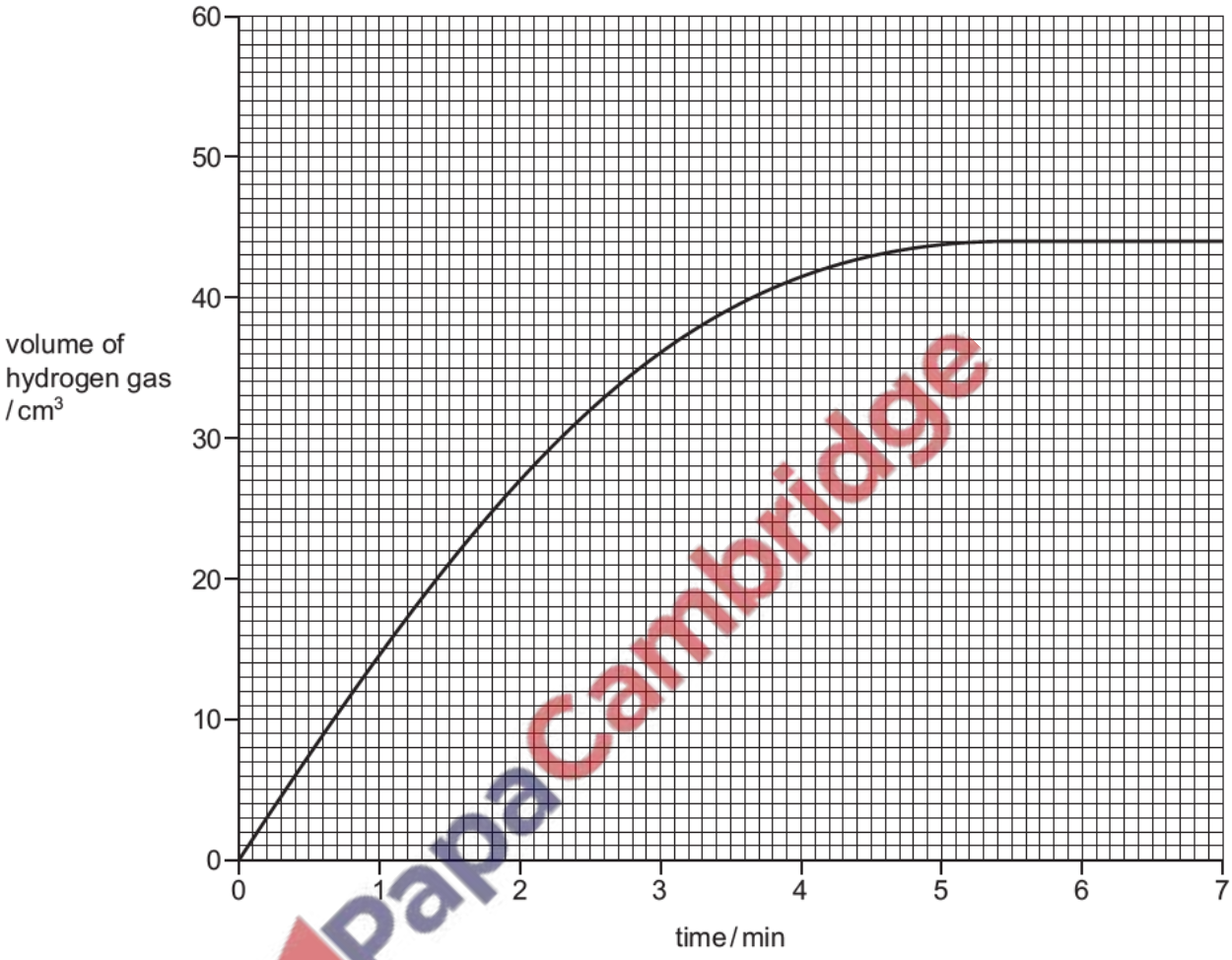


Fig. 8.1

(i) Deduce the volume of hydrogen gas released after 2 minutes.

volume of hydrogen gas = ... cm^3 [1]

(ii) The student repeats the experiment using dilute hydrochloric acid of a higher concentration.

All other conditions stay the same.

Draw a line on the grid in Fig. 8.1 to predict how the volume of hydrogen gas changes when dilute hydrochloric acid of a higher concentration is used. [2]

(b) (i) The student repeats the experiment with large pieces of iron.

All other conditions stay the same.

Describe how the rate of reaction differs when large pieces of iron are used.

..... [1]

(ii) The student repeats the experiment with iron powder at a temperature of 15 °C.

All other conditions stay the same.

Describe how the rate of reaction differs when a temperature of 15 °C is used.

..... [1]

(c) Hydrochloric acid also reacts with aqueous sodium hydroxide.

(i) Complete the word equation for this reaction.

hydrochloric acid	+	sodium hydroxide	→	....	+	.....

[2]

(ii) Write the formula of the ion present in all acids.

..... [1]

(iii) Choose from the list a possible pH value of aqueous sodium hydroxide.

Draw a circle around your chosen answer.

pH 2 **pH 4** **pH 7** **pH 13** [1]

(iv) State the colour of methyl orange in aqueous sodium hydroxide.

..... [1]

[Total: 10]

41. March/2023/Paper_ 0620/42/No.3

The Haber process is used to manufacture ammonia.

(a) State the main source of each gas used in the Haber process.

nitrogen .....

hydrogen .....

[2]

(b) The equation for the Haber process is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ/mol$$

The reaction is reversible. The forward reaction is exothermic.

(i) State what is meant by the symbol ΔH.

..... [1]

(ii) ΔH for the forward reaction is –92 kJ / mol.

State why this value shows that the forward reaction is exothermic.

..... [1]

(iii) State the typical conditions and name the catalyst used in the Haber process.

temperature ..... °C

pressure ..... kPa

catalyst .....

[3]

(iv) Complete Table 3.1 to show the effect, if any, when the typical conditions in the Haber process are changed. Use only the words **increases**, **decreases** or **no change**.

Table 3.1

change to typical conditions	effect on the rate of the forward reaction	effect on the concentration of $NH_3(g)$ at equilibrium
temperature increases	increases	
pressure decreases		
no catalyst	decreases	

[4]

(v) Explain in terms of collision theory why increasing the temperature increases the rate of the reaction.

.....

.....

.....

.....

..... [3]

(c) Ammonia reacts with an acid to form ammonium sulfate, $(NH_4)_2SO_4$.

(i) State the formula of the acid used.

..... [1]

(ii) State **one** use of ammonium sulfate.

..... [1]

(iii) Calculate the percentage composition by mass of nitrogen in $(NH_4)_2SO_4$.

percentage of nitrogen = ... % [2]

[Total: 18]