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vol. II. Topics

- Topic 09. The Periodic Table
- Topic 10. Metal
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01. Solids, Liquids and Gases

☑ ☒ ANSWER: **269** page

001.

Which of the following processes is a physical change?

- A** ice cube melting
- B** Iron rusting
- C** wood burning
- D** egg cooking

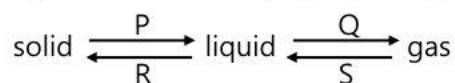
002.

Which statement accurately represents the arrangement of particles in a liquid?

- A** They are densely packed in a regular order.
- B** They vibrate but do not move from a fixed position.
- C** They move freely at high speed and are widely spaced.
- D** They are close together but have no regular arrangement.

003.

The diagram below shows the changes between solid, liquid, and gas states.



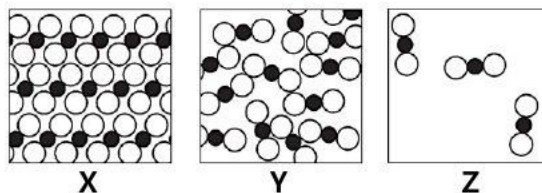
In which changes of state is energy being given out?

- A** P and Q
- B** P and R
- C** Q and R
- D** R and S

004.

Diagrams of the three states of matter for CO_2 are shown.

Which two diagrams show the states of matter before and after the sublimation of CO_2 ?



- A** X to Y
- B** X to Z
- C** Y to Z
- D** Z to Y

005.

A substance changes its state when the temperature changes.

What changes of state occur when the temperature of a substance is lowered?

P boiling

Q condensation

R freezing

S melting

A P and Q

B Q and R

C Q and S

D S only

006.

Compound X has a freezing point of -45°C and a boiling point of 195°C . A small sample of compound X is placed in an open beaker in an oven at a temperature of 110°C and at atmospheric pressure for 24 hours.

What happens to the sample of compound X?

A It boils.

B It melts.

C It sublimes.

D It evaporates.

007.

The table shows some changes. What rows describe the changes correctly in the table?

	physical change	chemical change
P	melting ice	rusting iron
Q	burning methane	cracking hydrocarbons
R	evaporating ethanol	burning ethanol
S	melting iron	evaporating ethanol

A P and Q

B P and R

C Q and S

D R and S

008.

A small sample of decane, which has a freezing point of -30°C and a boiling point of 175°C , is placed in an open beaker in an oven at a temperature of 80°C and at atmospheric pressure for 48 hours.

Which change occurs in the sample of decane?

A It melts.

B It boils.

C It sublimes.

D It evaporates.

013.

The melting and boiling points of three elements are shown, under conditions of 1 atm pressure.

	argon	nitrogen	oxygen
melting point [°C]	-189	-210	-218
boiling point [°C]	-186	-196	-183

Separate samples of argon, nitrogen, and oxygen are stored at a temperature of -200°C and a pressure of 1 atm.

How many of the samples are in a liquid state?

A 0

B 1

C 2

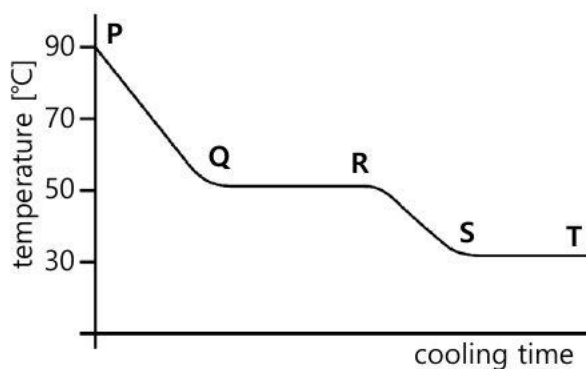
D 3

014.

Substance **X** is in a solid state at 40°C . The substance is heated to 90°C and its temperature measured as it cools down to room temperature.

The cooling curve is shown.

Between what times is substance **X** freezing?



A P and Q

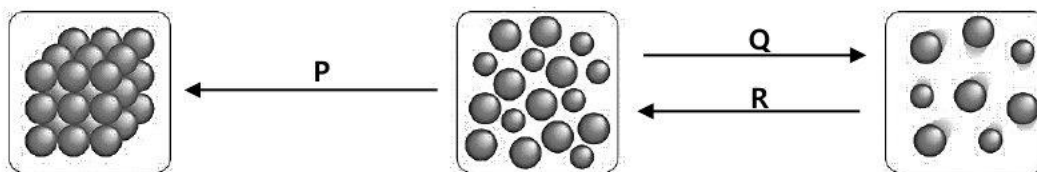
B Q and R

C R and S

D S and T

015.

The three rectangles depict the arrangements of particles in each of the three states of matter, with **P**, **Q**, and **R** representing the processes required for transitioning between these states.



Which processes do P, Q, and R represent?

	P	Q	R
A	freezing	evaporating	condensing
B	evaporating	freezing	melting
C	evaporating	freezing	melting
D	melting	evaporating	freezing

016.

The melting and boiling points of four different substances are shown.

element	W	X	Y	Z
melting point [°C]	-18	-127	159	24
boiling point [°C]	52	-42	232	592

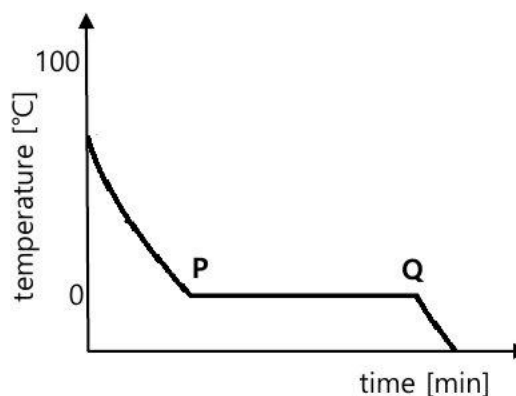
What substances have particles that vibrate about fixed positions at 0°C?

- A** W and X **B** W and Z **C** X and Y **D** Y and Z

017.

Which process is occurring between points P and Q on the shown part of a water cooling curve?

- A** Ice is melting.
B Steam is condensing into water.
C Particles are losing heat to the surrounding.
D The temperature of the water is decreasing.



018.

☑ ☒ ANSWER: **271** page

State two general properties of a solid.

1.

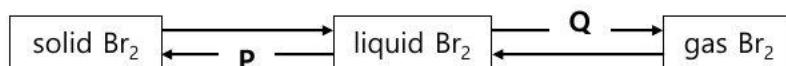
.....

2.

..... [2]

022.

Figure shows the physical states of bromine.



What are the changes in physical states for substances **P** and **Q**?

P

Q [2]

023.

The boiling point of a substance is at temperature **X** and its melting point is at temperature **Y**.

Complete the graph to show the change in temperature over time as the substance cools from temperature **P** to temperature **Q**.



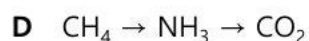
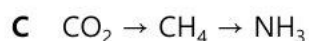
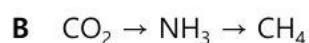
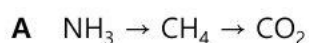
025.

Which row correctly describes the separation and motion of particles in a gas?

	separation of particles	motion of particles
A	widely spaced	fast movement
B	close together	fast movement
C	widely spaced	slow movement
D	close together	slow movement

026.

What is the order of diffusion rates, from slowest to fastest, for the gases ammonia, carbon dioxide, and methane?



027.

Which statement accurately describes Brownian motion?

A random movement of particles due to bombardment by smaller particles**B** random movement of particles due to bombardment by larger particles**C** random movement of particles from a low concentration to a high concentration**D** random movement of particles from a high concentration to a low concentration

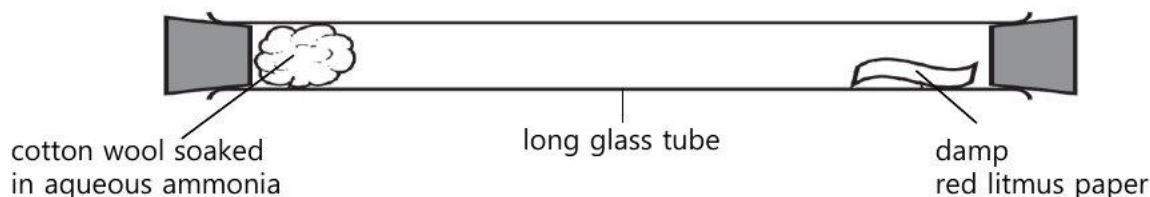
028.

Which two gases diffuse at the same rate, at the same temperature?

A oxygen and fluorine**B** chlorine and nitrogen dioxide**C** carbon monoxide and nitrogen**D** carbon dioxide and nitrogen dioxide

051.

Aqueous ammonia releases ammonia gas, which turns damp red litmus paper blue. The setup of the long glass tube is shown as below in the figure.



At first, the litmus paper does not turn blue, but after a short time, it turns blue.

Describe these results in terms of the kinetic particle theory.

.....

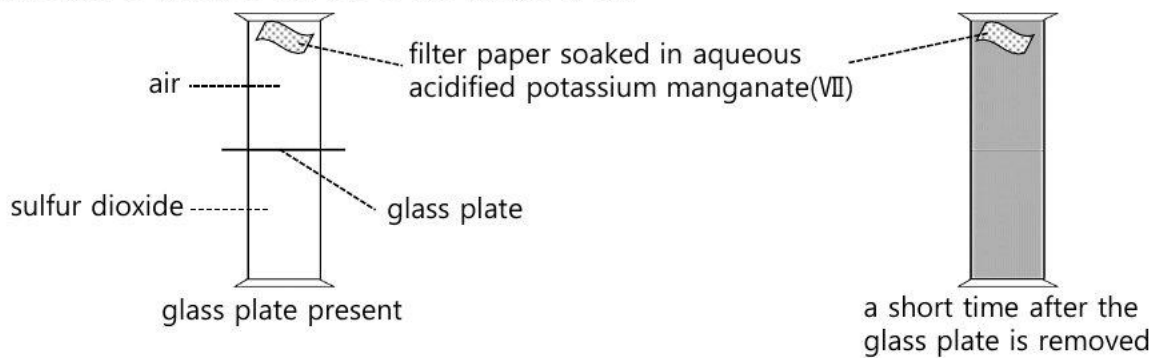
.....

.....

..... [3]

052.

The reaction of sulfur dioxide gas with aqueous acidified potassium manganate(VII) results in a colour change from purple to colourless. The figure shows a gas jar containing sulfur dioxide and another with air, separated by a glass plate. A piece of filter paper soaked in aqueous acidified potassium manganate(VII) is glued to the top of the gas jar of air.



After the removal of the glass plate, the filter paper initially remains purple, but after a short time, it turns colorless.

What is the explanation for these results in terms of the kinetic particle theory?

.....

.....

..... [3]

053.

What is the correct row concerning elements, mixtures, and compounds?

	metallic element	non-metallic element	mixture	compound
A	brass	ethane	copper	sulfur
B	copper	sulfur	brass	ethane
C	brass	sulfur	copper	ethane
D	copper	ethane	brass	sulfur

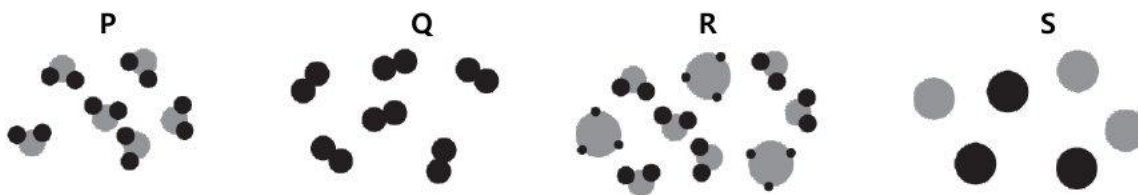
054.

What statement shows an explanation for ethanol being a compound?

- A** Ethanol has the same chemical properties as both hydrogen and oxygen.
- B** The number of hydrogen and oxygen atoms in a molecule of ethanol is variable.
- C** The hydrogen and oxygen atoms in a molecule of ethanol can be separated using physical means.
- D** The hydrogen and oxygen atoms in a molecule of ethanol can only be separated by chemical means.

055.

Below are diagrams showing some elements, compounds, and mixtures.



What row shows a description of the substances?

	P	Q	R	S
A	mixture of elements	mixture of compounds	element	compound
B	mixture of compounds	compound	mixture of elements	element
C	compound	element	mixture of compounds	mixture of elements
D	element	compound	mixture of elements	mixture of compounds

100.

There are two different naturally occurring atoms of copper, ^{63}Cu and ^{65}Cu .

- ① What is the term used to describe atoms of the same element with different nucleon numbers?

..... [1]

- ② Given that the atomic number of copper is 29, fill in the table to show the number of protons, neutrons, and electrons in the particles of copper shown.

particles	^{63}Cu	$^{65}\text{Cu}^{2+}$
protons		
neutrons		
electrons		

- ③ The relative atomic mass of an element is the average mass of its naturally occurring atoms.
What is the relative atomic mass of copper deduced from the shown percentage of naturally occurring atoms in this sample?
(Give your answer to one decimal place.)

^{63}Cu	^{65}Cu
70%	30%

..... [1]

101.

Lithium has two naturally occurring types of atoms, ^6Li and ^7Li .

- ① What name is given to atoms of the same element that have different nucleon numbers?

..... [1]

- ② Complete table to show the number of protons, neutrons and electrons in the atom and ion of lithium shown. [3]

	protons	neutrons	electrons
^6Li			
$^7\text{Li}^+$			

- ③ Table shows the relative abundances of the two naturally occurring lithium isotopes.

atom	^6Li	^7Li
relative abundance	10%	90%

What is the relative atomic mass of lithium when calculated to one decimal place?

..... [1]



110.

Which two particles have the same electronic structure (or configurations)?

- A N and O^{2-} B Ca^{2+} and S^{2-} C Na^+ and Cl^- D Na and Mg^{2+}

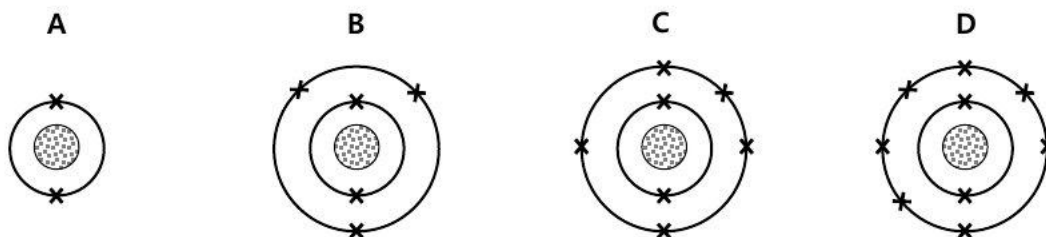
111.

Which two particles have identical electronic structure?

- A N and F^- B O^{2-} and Na C K^+ and Mg^{2+} D Ca^{2+} and S^{2-}

112.

Which diagram shows the arrangement of the outer-shell electrons in a noble gas?



113.

Which particle does **not** have the same electronic configuration as the nitride ion, which has the formula N^{3-} ?

- A Cl^- B Al^{3+} C O^{2-} D Na^+

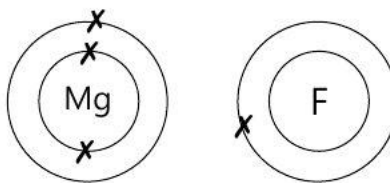
114.

Which statement about elements in the Periodic Table is correct?

- A The electronic configuration of a Ca^{2+} ion is 2,8,8,2.
 B A potassium ion, K^+ , has the same electronic configuration as a chloride ion, Cl^- .
 C The halogens are in Group VI and so their atoms have six electrons in their outer shell.
 D Magnesium is in Period 3 and so a magnesium ion, Mg^{2+} , has three occupied electron shells.

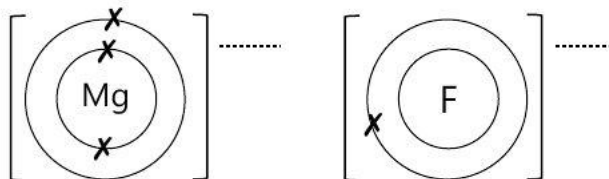
149.

When magnesium reacts with fluorine, it produces the ionic compound known as magnesium fluoride. The figure shows the electronic configurations for a magnesium atom and a fluorine atom.



- ① The formation of ions occurs through the transfer of electrons from atoms of magnesium to atoms of fluorine.

What are the electronic configurations of one magnesium ion and one fluoride ion as shown in the dot-and-cross diagrams in Figure? [3]



- ② What is the formula of magnesium fluoride?

..... [1]

- ③ A solution that conducts electricity is formed when solid magnesium fluoride is dissolved in water.

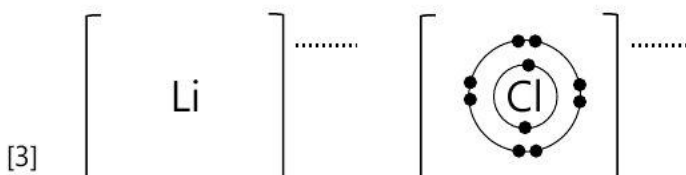
What is another change that can be made to solid magnesium fluoride to allow it to conduct electricity?

..... [1]

150.

Lithium chloride (LiCl) is classified as an ionic compound.

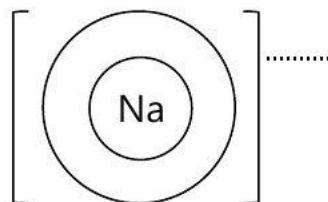
Complete the dot-and-cross diagram to show the electron arrangement and charges of the ions in lithium chloride.



151.

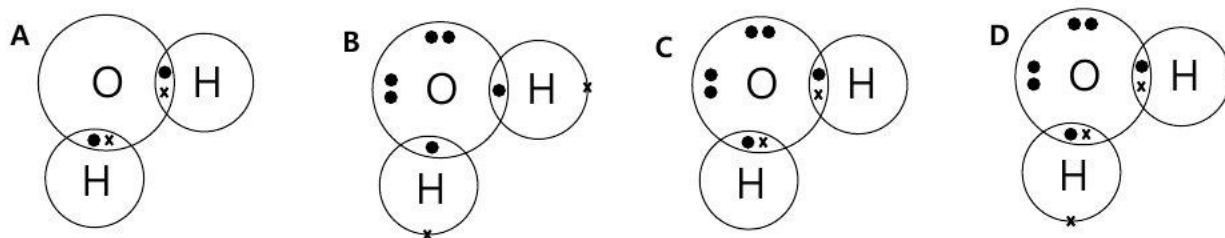
Complete figure to show:

- the electronic configuration of a sodium ion
- the charge on the ion.



174.

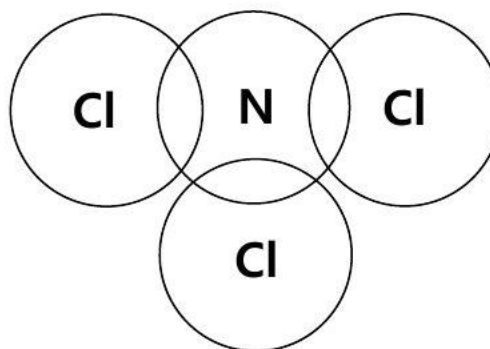
Which diagram correctly shows the outer-shell electron arrangement in water, H_2O , given that it is a covalent molecule?



✓ (X) ANSWER: **298** page

175.

Complete a dot-and-cross diagram showing the electron arrangement in a molecule of nitrogen trichloride (NCl_3), a covalent compound. (Show outer electrons only.)



176.

Nitrogen molecules, with the formula N_2 , have the following properties:

- | | |
|---|---|
| - melting point of -210°C | - boiling point of -196°C |
| - non-conductor of electricity when solid | - insoluble in water |

① What is the type of bonding between the atoms in an N_2 molecule?

..... [1]

② State, in terms of attractive forces between particles, why nitrogen has a low melting point.

.....
 [1]

③ Why does not nitrogen conduct electricity?

.....
 [1]

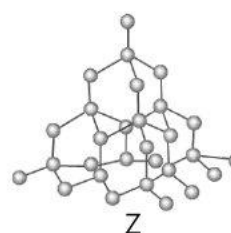
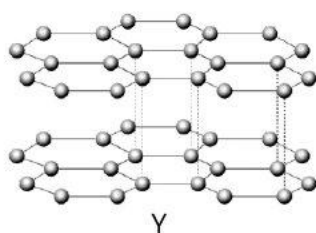
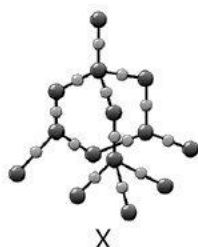
196.

Which of the following explains why graphite can be used as a lubricant?

- A All atoms in graphite are carbon.
- B Each carbon atom forms four bonds.
- C Graphite has a macromolecular structure.
- D Layers of graphite can slide over each other.

197.

What are the structures of the three macromolecules X, Y, and Z?



	X	Y	Z
A	graphite	diamond	silicon(IV) oxide
B	silicon(IV) oxide	graphite	diamond
C	diamond	graphite	silicon(IV) oxide
D	diamond	silicon(IV) oxide	graphite

198.

Which of the following statement correctly describes the properties of diamond and silicon (IV) oxide?

- A They are hard, with a high melting point, and are electrical insulators.
- B They are soft, with a low melting point, and are electrical insulators.
- C They are brittle, with a low melting point, and are insoluble in water.
- D They are malleable, with a high melting point, and are electrical conductors.

199.

What substance is characterised as a macromolecule?

- A magnesium
- B ammonia
- C graphite
- D calcium chloride

01. Chemical Names and Formulae

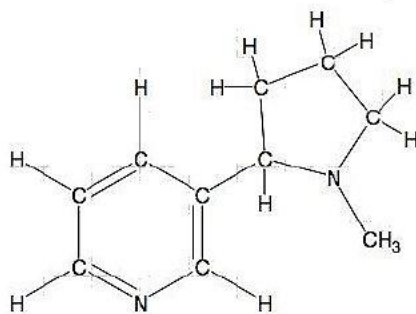
☑ ☒ ANSWER: 307 page

227.

Nicotine is an addictive substance found in cigarettes.

Which formula represents nicotine?

- A** $C_9H_{10}N_2$ **B** $C_9H_{12}N_2$ **C** $C_{10}H_{12}N_2$ **D** $C_{10}H_{14}N_2$



228.

What formula represents the empirical formula?

- A** $C_2H_6O_2$ **B** $C_3H_4O_2$
C C_4H_9COOH **D** $CH_3CH_2CH_2COOH$

229.

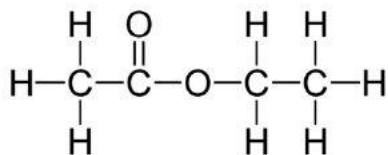
What is the name given to the type of formula, $CH_3CH=CH_2$, that represents an alkene?

- A** general **B** empirical **C** displayed **D** structural

230.

The structure of an ethyl ethanoate molecule is shown in the diagram.

Which molecular formula shows a molecule of ethyl ethanoate?

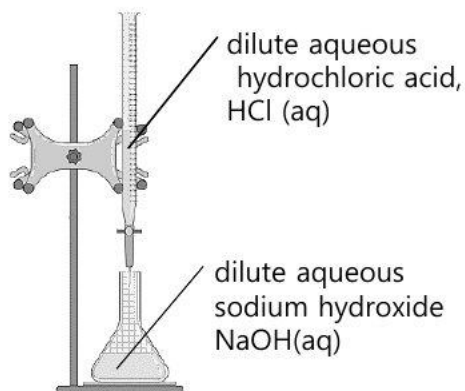


- A** CHO **B** C_2H_4O **C** $C_4H_8O_2$ **D** $C_4(H_2)_3(O_2)$

284.

The concentration of a sample of dilute aqueous sodium hydroxide is determined using a shown apparatus through the process of titration.

What information is required to calculate the concentration of the dilute aqueous sodium hydroxide in mol/dm³?



	concentration of HCl	volume of HCl used	molar mass of HCl	volume of NaOH used	molar mass of NaOH
A	X	✓	✓	✓	X
B	✓	X	X	X	✓
C	✓	✓	X	✓	X
D	✓	✓	✓	✓	✓

285.

Magnesium reacts with steam. $\text{Mg} + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{H}_2$

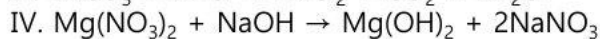
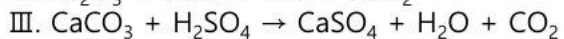
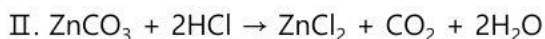
When 2.43 g of magnesium reacts with an excess of steam, the products are 4.03 g of magnesium oxide and 0.20 g of hydrogen.

What is produced when 7.29 g of magnesium reacts with an excess of steam?

- A** 9.08 g of magnesium oxide and 0.40 g of hydrogen.
- B** 10.05 g of magnesium oxide and 0.48 g of hydrogen.
- C** 10.28 g of magnesium oxide and 0.56 g of hydrogen.
- D** 12.09 g of magnesium oxide and 0.60 g of hydrogen.

286.

Which equations are balanced?



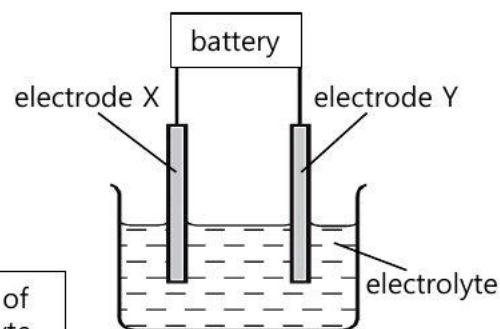
- A** I and II
- B** I and III
- C** II and III
- D** III and IV

335.

Electrode X is undergoing oxidation, while electrode Y is experiencing reduction in the electrolysis diagram.

Which row indicates the direction in which electrons are moving in the external circuit and the positive ions in the electrolyte are moving?

	direction of movement of electrons in external circuit	direction of movement of positive ions in electrolyte
A	$X \rightarrow Y$	$Y \rightarrow X$
B	$Y \rightarrow X$	$X \rightarrow Y$
C	$Y \rightarrow X$	$Y \rightarrow X$
D	$X \rightarrow Y$	$X \rightarrow Y$



336.

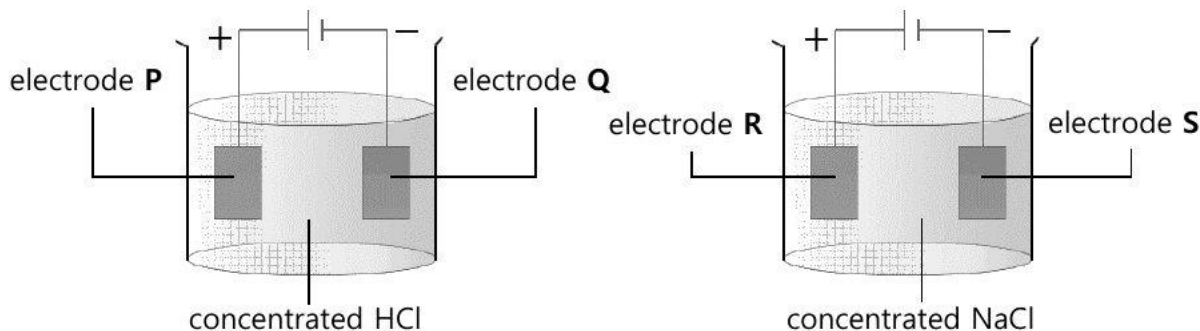
A dilute sodium chloride solution is subjected to electrolysis with the use of carbon electrodes.

Which substance is formed as a product at the anode?

- A** sodium **B** oxygen **C** hydrogen **D** chlorine

337.

The diagram shows the process of electrolysis using carbon electrodes in both concentrated hydrochloric acid and concentrated aqueous sodium chloride solutions.



At which electrodes is H_2 produced?

- A** electrode Q only **B** electrode R only
C electrodes Q and S **D** electrodes P and R

383.

Below are four statements about hydrogen fuel cells.

- P. The hydrogen fuel is extracted from the air.
- Q. In the fuel cell, hydrogen combines with oxygen.
- R. Carbon dioxide and water are produced in the fuel cell.
- S. The fuel cell converts chemical energy into electrical energy.

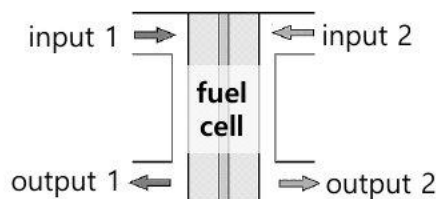
What are the correct statements?

- A** P and Q **B** P and R **C** Q and S **D** R and S

384.

The flow diagram shows a hydrogen–oxygen fuel cell.

Which row shows the inputs and outputs?



	input 1	input 2	output 1	output 2
A	fuel	oxygen	water	electricity
B	fuel	hydrogen	water	electricity
C	electricity	water	hydrogen	oxygen
D	electricity	electrolyte	hydrogen	oxygen

385.

What are the correct statements about hydrogen fuel cells?

- P. The overall reaction is endothermic.
- Q. The overall reaction is $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$.
- R. Water is formed as the only waste product.
- S. Both water and carbon dioxide are formed as waste products.

- A** P and Q **B** Q and R **C** R and S **D** P and S

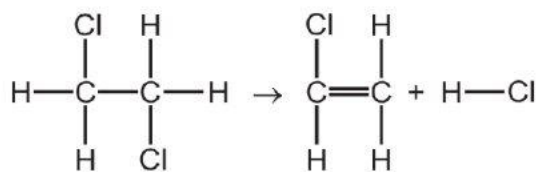
386.

What are the gases that are used to generate electricity in a fuel cell?

- A** hydrogen and oxygen **B** hydrogen and methane
- C** carbon dioxide and oxygen **D** methane and carbon dioxide

433.

Chloroethene ($\text{CH}_2=\text{CHCl}$) can be manufactured from 1,2-dichloroethane ($\text{CH}_2\text{Cl}-\text{CH}_2\text{Cl}$). The chemical equation and structural formula can be represented as shown.



bond	C-C	C=C	C-Cl	C-H	H-Cl
bond energy [kJ/mol]	350	610	340	410	430

Use the bond energies in the table to calculate the energy change, in kJ/mol, of the reaction.

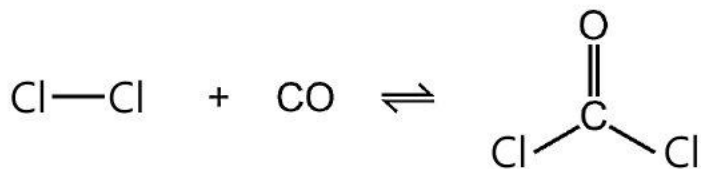
- ① How much energy is required to break the bond? kJ [1]
- ② How much energy is released when a bond is formed? kJ [1]
- ③ Calculate the energy change of the reaction. kJ/mol [3]
- ④ Deduce whether the energy change for this reaction is exothermic or endothermic.
Give a reason for your answer

.....

..... [1]

434.

The reaction between chlorine and carbon monoxide is shown as follows. When one mole of chlorine reacts with one mole of carbon monoxide, releasing 230 kJ of energy, some bond energies are provided in the table.



bond	energy [kJ/mol]
Cl-Cl	240
C=O	745
C-Cl	400

What is the energy of the bond between C and O in carbon monoxide, CO, when calculated using the given information?

bond energy in carbon monoxide, CO = kJ/mol [3]

485.

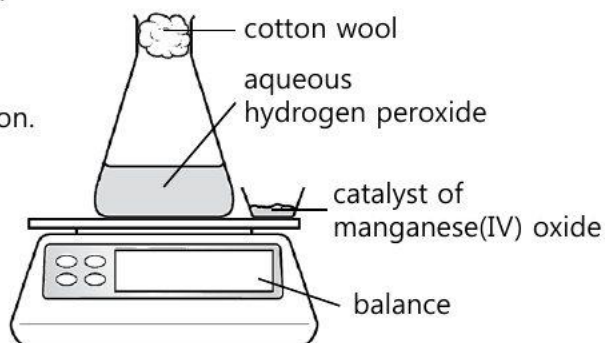
An investigation involves the decomposition of hydrogen peroxide in the presence of a catalyst of manganese(IV) oxide.



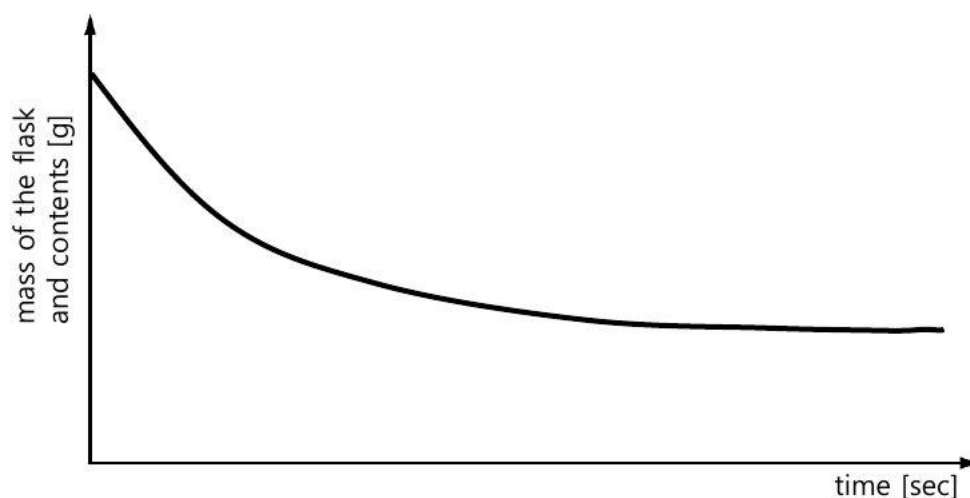
The diagram shows the equipment used in the investigation.

This method is used:

- the catalyst is added to the aqueous hydrogen peroxide
- the stop-clock is started
- the mass of the flask and contents is recorded at regular time intervals.



A graph of the mass of the flask and contents against time is shown.



- ① What is the reason for the decrease in the mass of the flask and its contents as time increases?

..... [1]

- ② State what happens to the rate of the reaction as time increases.

.....

..... [2]

- ③ Draw a line on the graph for the experiment at a higher temperature.

492.

Aqueous hydrogen peroxide, H_2O_2 , slowly forms water and oxygen at room temperature and pressure, r.t.p. The equation shown is for a reaction catalysed by manganese(IV) oxide.

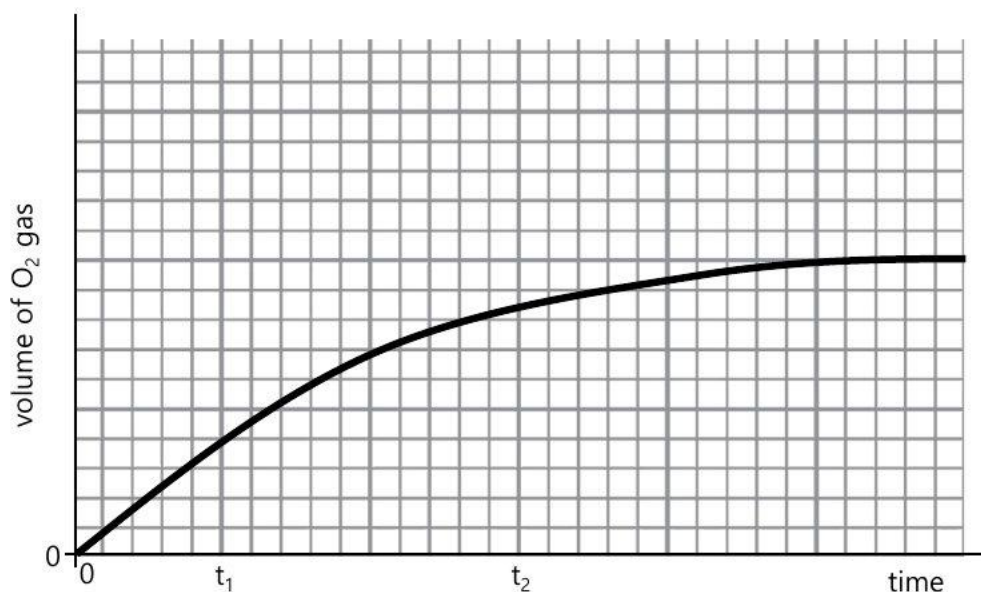


- ① What is the test for oxygen gas?

test

observations [2]

- ② A student researches the rate of formation of oxygen gas when manganese(IV) oxide is added to aqueous hydrogen peroxide. The volume of oxygen gas formed is measured at regular time intervals at r.t.p., and the results are plotted onto the graph in the figure.



- Ⓐ Describe how the graph in figure shows the rate of reaction at time t_2 , is lower than at time t_1 .

..... [1]

- Ⓑ State how the graph in figure shows the rate of reaction at time t_2 , is lower than at time t_1 .

.....

..... [2]

- Ⓒ On figure, sketch the graph obtained when the experiment is repeated using aqueous hydrogen peroxide at a higher temperature. All other conditions remain the same. [2]

524.

What is the identity of solid **X** which changes color from white to blue upon the addition of water?

- A** hydrated cobalt(II) chloride **B** hydrated copper(II) sulfate
C anhydrous cobalt(II) chloride **D** anhydrous copper(II) sulfate

525.

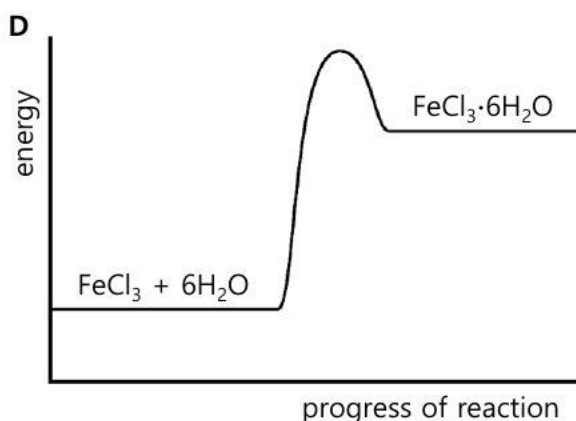
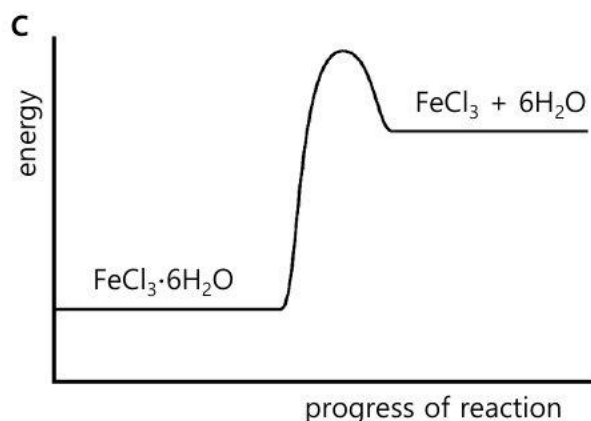
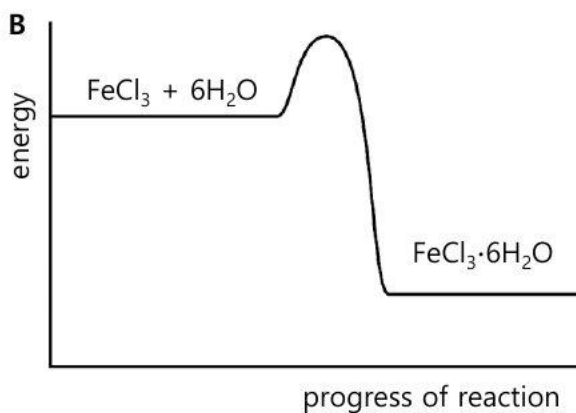
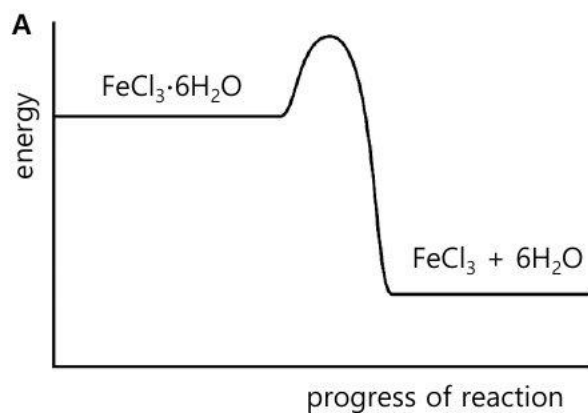
What reaction shows a colour change from white to blue?

- A** heating hydrated copper(II) sulfate
B heating anhydrous copper(II) sulfate
C adding water to hydrated copper(II) sulfate
D adding water to anhydrous copper(II) sulfate

526.

Upon the addition of water to anhydrous iron(III) chloride, FeCl_3 , energy is released and hydrated iron(III) chloride, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, is produced. $\text{FeCl}_3 + 6\text{H}_2\text{O} \rightleftharpoons \text{FeCl}_3 \cdot 6\text{H}_2\text{O}$

Which reaction pathway diagram corresponds to the formation of anhydrous iron(III) chloride in the reverse reaction?



583.

Which column shows a base and an oxidising agent?

	A	B	C	D
base	proton donor	proton donor	proton acceptor	proton acceptor
oxidising agent	electron donor	electron acceptor	electron donor	electron acceptor

584.

Four redox equations and statements about the equations are shown below.

	reaction	statement
P	$C + O_2 \rightarrow CO_2$	carbon is oxidised
Q	$CO_2 + C \rightarrow 2CO$	carbon is oxidised
R	$CO_2 + C \rightarrow 2CO$	carbon dioxide is oxidised
S	$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$	iron(III) oxide is oxidised

What are the correct statements about these equations?

A P only**B** P and Q**C** P, Q and R**D** Q, R and S☑ ☒ ANSWER: **364** page

585.

Dilute phosphoric acid is a weak acid which contains phosphate ions, PO_4^{3-} .

① What is the definition of the term 'acid'?

..... [1]

② What does "weak" mean in the term "weak acid"?

..... [1]

③ What is the oxidation number of phosphorus in the PO_4^{3-} ion? [Show your working.]

..... [2]

620.

In which reaction does an acid react with a base?

- A** Dilute sulfuric acid is added to a piece of magnesium ribbon producing hydrogen.
- B** Aqueous sodium hydroxide is added to solid ammonium sulfate producing gaseous ammonia.
- C** Dilute sulfuric acid is added to aqueous barium chloride producing a white precipitate of barium sulfate.
- D** Aqueous sodium hydroxide is added to aqueous copper(II) sulfate producing a blue precipitate of copper(II) hydroxide.

621.

Statements about four different acids are listed.

- Hydrobromic acid, HBr, is a strong acid.
- A 0.01 mol/dm³ solution of ethanoic acid has a pH of 3.4.
- A 0.01 mol/dm³ solution of hydrochloric acid has a pH of 2.
- Ethanoic acid is a slightly stronger acid than trimethylethanoic acid.

Which are the pH values for a 0.0100 mol/dm³ HBr solution and a 0.0100 mol/dm³ trimethylethanoic acid solution?

	pH of 0.01 mol/dm ³ HBr	pH of 0.01 mol/dm ³ trimethylethanoic acid
A	1.5	3.3
B	2.0	3.4
C	2.0	3.5
D	2.5	3.5

622.

An ethanoic acid sample and a hydrochloric acid sample have same concentrations.

How do the hydrogen ion concentration and pH of ethanoic acid compare to those of hydrochloric acid?

	ethanoic acid compared to hydrochloric acid	
	H ⁺ ion concentration	pH
A	lower	lower
B	lower	higher
C	higher	lower
D	higher	higher

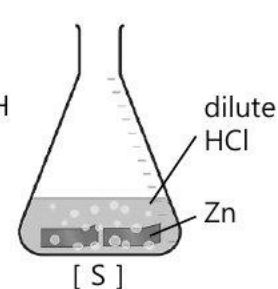
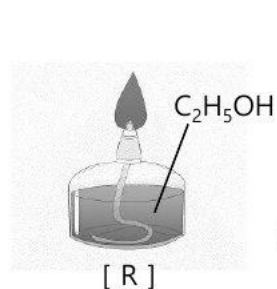
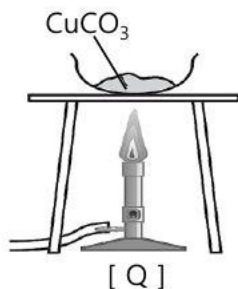
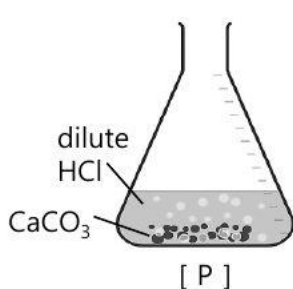
683.

What is the observation when a few drops of aqueous substance **X** are added to concentrated aqueous substance **Y**?

	X	Y	observation
A	ammonia	potassium carbonate	fizzing
B	barium chloride	iron(III) sulfate	brown precipitate
C	sodium hydroxide	zinc chloride	white precipitate
D	acidified potassium manganate(VII)	sodium sulfite	purple solution

684.

Which of the following reactions result in the production of water?

**A** P and Q**B** P and R**C** P, Q and R**D** Q, R and S

685.

What gases are produced when copper(II) nitrate and zinc carbonate are heated strongly in separate test-tubes?

	copper(II) nitrate	zinc carbonate
A	nitrogen dioxide only	carbon dioxide and oxygen
B	nitrogen dioxide only	carbon dioxide only
C	oxygen and nitrogen dioxide	carbon dioxide and oxygen
D	oxygen and nitrogen dioxide	carbon dioxide only

686.

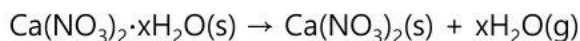
In a factory, waste water is treated using lime (calcium oxide).

What substance is removed by using of lime?

A ammonia**B** sulfuric acid**C** sodium chloride**D** sodium hydroxide

728.

The crystals of calcium nitrate are in a hydrated form with the chemical formula $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$, where x is a whole number of molecules of water. An experimenter heats the crystals to remove the molecules of water.



- ① What term is used to describe calcium nitrate after water molecules have been removed?

..... [1]

- ② He heats a sample of $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$ and forms 2.46 g of $\text{Ca}(\text{NO}_3)_2$ and 0.0600 moles of H_2O . Calculate the value of x . (Use the following steps.)

- a) What is the M_r of $\text{Ca}(\text{NO}_3)_2$?

..... [1]

- b) Calculate the number of moles of $\text{Ca}(\text{NO}_3)_2$ formed.

..... [1]

- c) Determine the value of x in $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$.

..... [1]

729.

State the meaning of the term thermal decomposition.

.....

..... [2]

730.

What are two compounds that react with dilute sulfuric acid to produce aqueous zinc sulfate?

1.

2. [2]

526. Answer (C)

In the original reaction, when water is added to anhydrous iron(III) chloride (FeCl_3), hydrated iron(III) chloride ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) is formed and **energy is released**, making it an **exothermic reaction**.

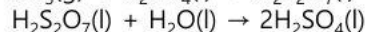
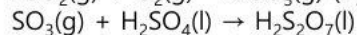
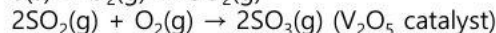
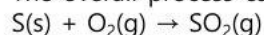
However, the **reverse reaction**, the formation of anhydrous iron(III) chloride from its hydrated form, would **require an input of energy to remove the water molecules**. This makes the reverse reaction **endothermic**, and the reaction profile would show an increase in energy.

Therefore the correct answer is **C**.

527. Answer (D)

The **Contact process** is an industrial method for the **production of sulfuric acid**. In this process, sulfur dioxide is oxidized to sulfur trioxide using a catalyst, usually **vanadium(V) oxide**. This sulfur trioxide is then absorbed in sulfuric acid or water to form more sulfuric acid.

The overall process can be represented as follows:



This sequence of reactions demonstrates the production of sulfuric acid from sulfur via the Contact process. The **sulfuric acid can then react with ammonia to produce ammonium sulfate**.

Therefore the correct answer is **D**.

528. Answer (C)

When the reaction reaches **equilibrium**, the **rates of the forward and reverse reactions are equal**.

If **more Z is added** to the system, the equilibrium will shift **to reduce the increase in Z's concentration**. According to Le Chatelier's principle, the system will try to counteract this change by **shifting the position of equilibrium to the left**, towards the reactants. As a result, the reaction will **consume more of Z (and Y)**, and **produce more of V, W, and X**, causing their concentrations to increase.

Therefore the correct answer is **C**.

529. Answer (C)

A higher temperature would favor the forward reaction according to Le Chatelier's principle but could also lead to unwanted side reactions and increased equipment costs. Therefore, a balance is sought at around 450°C .

Pressure does not significantly affect the rate because there are equal numbers of moles of gas on both sides of the equation. However, lower pressure is preferred for safety and cost reasons.

Vanadium(V) oxide (V_2O_5), not iron, is used as a catalyst to speed up the reaction without being consumed in it.

Therefore the correct answer is **C**.

530. Answer (B)

The position of equilibrium shifts to the right and the rate of the reverse reaction increases. This is because the **decomposition of N_2O_4 into NO_2 is an endothermic reaction**. According to **Le Chatelier's Principle**, if a **system at equilibrium is subjected to a change, the system will adjust itself to counteract that change**.

In this case, when the **temperature is increased**, the system tries to **absorb the extra heat by favoring the endothermic reaction**, which is the forward reaction ($\text{N}_2\text{O}_4(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$). This shifts the position of equilibrium to the right, meaning more NO_2 is produced.

Furthermore, according to the **Collision Theory**, as the **temperature increases**, the molecules move faster and collide more frequently and with greater energy. This **increases the rate of both the forward and reverse reactions**, but since the equilibrium has shifted to the right, we can say the rate of the reverse reaction ($2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_4(\text{g})$) has increased.

Therefore the correct answer is **B**.

531. Answer (B)

The reaction is a reversible reaction that results in the formation of ammonia. **According to Le Chatelier's principle**, if a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium moves to counteract the change.

In this reaction, there are **4 moles of gas on the left-hand side** (1 of N_2 and 3 of H_2) and only **2 moles of NH_3 gas on the right-hand side**. So, if the **pressure is increased**, the position of equilibrium will shift to the side with fewer gas molecules to decrease the pressure. Thus, increasing the pressure would favor the forward reaction, resulting in a higher yield of ammonia.

Adding a catalyst would increase the rate of both the forward and reverse reactions equally, so it would not change the yield. Increasing the temperature would favor the endothermic reverse reaction, reducing the yield of ammonia. Reducing the concentration of nitrogen would shift the equilibrium to the left, according to Le Chatelier's principle, also reducing the yield of ammonia.

Therefore the correct answer is **B**.

643. Answer

- ① $\text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2$
 ② a no more fizzing or bubbling
 → because no more H_2 gas is being produced
 b solid Mg no longer dissolves or is still visible in the mixture
 → as it is determined to be in excess

When magnesium reacts with dilute sulfuric acid, hydrogen gas is produced, causing visible fizzing or bubbling. As the reaction nears completion and the hydrogen gas production ceases, the fizzing stops. Furthermore, since excess magnesium is added to ensure a complete reaction with sulfuric acid, the presence of undissolved magnesium in the mixture confirms that the reaction has reached completion.

02. Oxide

						644	A	645	B
646	D	647	D	648	B	649	B	650	D
651	C	652	D	653	A	654	A	655	B
656	A	657	A	658	D	659	D	660	D
661	C	662	C	663	A	664	C	665	A
666	A	667	B	668	D				
answers to Theory questions (669. ~ 678.) are included in the detailed explanations									

644. Answer (A)

1 is K, 2 is Mg, 3 is Si, and 4 is S.

Basic oxides are typically formed by metals, as they tend to donate electrons and form positive ions. On the other hand, non-metals tend to form acidic or amphoteric oxides.

In the given options, K and Mg are metals. When they react with oxygen, they form metal oxides that exhibit basic properties. Si and S, however, are non-metals.

Therefore, the correct answer is **A**.

645. Answer (B)

Sulfur oxide, specifically sulfur dioxide (SO_2) is used as a preservative to prevent bacterial growth and food spoilage. **It is often used in canned fruits and vegetables, dried fruits, and wine-making.** When SO_2 dissolves in water, it forms sulfurous acid, which prevents the growth of bacteria and fungi that cause food to spoil.

Therefore, the correct answer is **B**.

646. Answer (D)

When metal oxides react with water, they produce basic solutions, which can turn universal indicator paper blue or purple. **When non-metal oxides react with water, they produce acidic solutions, which can turn universal indicator paper red or orange.** Sodium carbonate reacts with acidic solutions to produce carbon dioxide gas. Therefore, since P produces a basic solution, it is likely the oxide of a metal, while Q produces an acidic solution when dissolved in water and is likely the oxide of a non-metal.

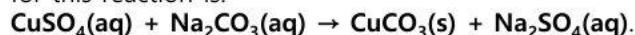
647. Answer (D)

Na_2O is a basic oxide as it reacts with water to form a solution of NaOH . **NaOH is a strong alkaline solution, and therefore, Na_2O can be described as having basic properties.** SO_2 , on the other hand, reacts with water to form sulfurous acid, which is a weak acid.

Therefore the correct answer is **D**.

697. Answer (D)

The reaction mixture containing aqueous Na_2CO_3 and aqueous CuSO_4 will produce a precipitate. This is due to the formation of an insoluble copper carbonate (CuCO_3) when the two solutions react. The equation for this reaction is:

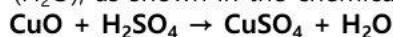


The copper carbonate is insoluble and will form a solid precipitate in the solution

Therefore the correct answer is **D**.

698. Answer (D)

Add copper(II) oxide (CuO) to dilute sulfuric acid (H_2SO_4). This step allows copper(II) oxide to react with the acid to form copper(II) sulfate (CuSO_4) and water (H_2O), as shown in the chemical equation:



After this reaction, add excess aqueous sodium carbonate (Na_2CO_3) to the mixture. The excess sodium carbonate ensures that all the copper ions are converted into copper(II) carbonate (CuCO_3) by a double displacement reaction, as seen in the chemical equation:

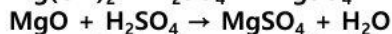
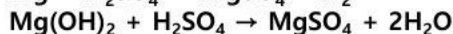
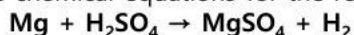


Finally, filter off the precipitate, which is the copper(II) carbonate. The precipitate is separated from the solution and can be collected.

Therefore the correct answer is **D**.

699. Answer (C)

The chemical equations for the reactions:

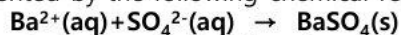


$\text{Mg}(\text{NO}_3)_2$ does not react with dilute sulfuric acid to form magnesium sulfate. Instead, it will result in a neutralization reaction producing water, magnesium nitrate, and sulfuric acid.

Therefore the correct answer is **C**.

700. Answer (B)

The reason is that **most sulfate salts are soluble**, but **barium sulfate is an exception to this rule**. This can be represented by the following chemical reaction:

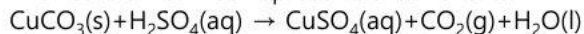


The equation represents the ions in solution combining to form a solid barium sulfate compound, indicated by the (s) which stands for solid. The **solid will settle to the bottom** of the solution, indicating that it is **not soluble**.

Therefore the correct answer is **B**.

701. Answer (C)

The reaction can be represented as follows:



The solid copper(II) carbonate is **in excess**, meaning some of **it will remain unreacted**. The mixture thus contains the desired copper(II) sulfate solution and the unreacted copper(II) carbonate solid.

To obtain the solid copper(II) sulfate, the first step is **filtration**. This process **separates the solid copper(II) carbonate from the copper(II) sulfate solution**.

The filtered copper(II) sulfate solution is then subjected to **crystallisation to obtain solid copper(II) sulfate**. During crystallisation, the **solution is heated to evaporate some of the water, and then it is left to cool**. As it cools, the copper(II) sulfate starts to form crystals, which can be collected and dried.

Therefore the correct answer is **C**.

702. Answer (D)

Potassium nitrate (KNO_3) decomposes upon heating to produce potassium nitrite and oxygen gas.



Magnesium carbonate (MgCO_3) decomposes upon heating to produce magnesium oxide and carbon dioxide gas.



Potassium carbonate (K_2CO_3) does not undergo a reaction when heated under normal conditions using a Bunsen burner.

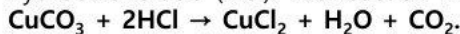
Therefore, the correct answer is **D**.

703. Answer (B)

Copper is a transition metal that does not react with acids under normal conditions due to its low reactivity, so method J (acid + metal) cannot be used to make copper(II) chloride.

Method K (acid + metal oxide), can be used if copper oxide reacts with an acid like hydrochloric acid. The reaction would be: $\text{CuO} + 2\text{HCl} \rightarrow \text{CuCl}_2 + \text{H}_2\text{O}$.

Method L (acid + metal carbonate) can be used if copper carbonate reacts with an acid such as hydrochloric acid (HCl). The reaction would be:

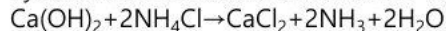


Therefore, the correct answer is **B**.

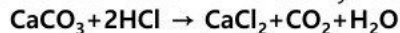
704. Answer (A)

The hydrogen gas is released as bubbles, but water is not directly formed in the reaction.

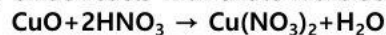
Calcium hydroxide and ammonium chloride react:



Calcium carbonate reacts with dilute hydrochloric acid:



Copper(II) oxide reacts with dilute nitric acid:



Therefore, the correct answer is **A**.