Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2010

PHYSICS AND CHEMISTRY – HIGHER LEVEL

MONDAY, 21 JUNE – MORNING, 9:30 to 12:30

Six questions to be answered.
Answer any **three** questions from **Section I** and any **three** questions from **Section II**.
All questions carry equal marks.
However, in each section, one additional mark will be given to
each of the first two questions for which the highest marks are obtained.

SECTION I – PHYSICS (200 marks)

1. Answer **eleven** of the following items, (*a*), (*b*), (*c*), etc. All the items carry equal marks.
Keep your answers short.

(*a*) Define *displacement*.

(*b*) State *Newton's first law of motion.*

(*c*) Define the unit of work, i.e. *the joule*.

(*d*) Name the two optical phenomena that occur when white light passes through a prism as shown in **Figure 1**.

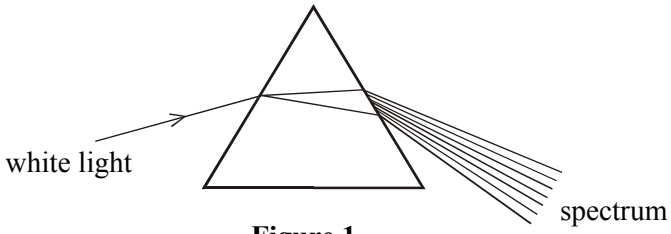


Figure 1

(*e*) Give two properties of the image formed by reflection of an object in a plane mirror.

(*f*) **Figure 2** shows a ray of light entering an optical fibre.
How does light travel through the fibre?

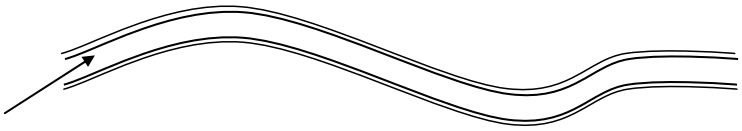


Figure 2

(*g*) What type of wave is a water wave? Justify your answer.

(*h*) Small particles are observed to be in continuous agitation when suspended in a liquid or a gaseous medium, e.g. smoke particles in air. Name this phenomenon.

(*i*) State two assumptions of the kinetic theory of gases.

(*j*) Sketch the electrical field around a small, isolated, positively charged sphere.

(*k*) State two factors that affect the capacitance of a parallel plate capacitor.

(*l*) **Figure 3** shows a conducting rod suspended between the poles of a strong magnet. The lower end of the conductor dips into mercury. Why does the conductor move when the current is switched on?

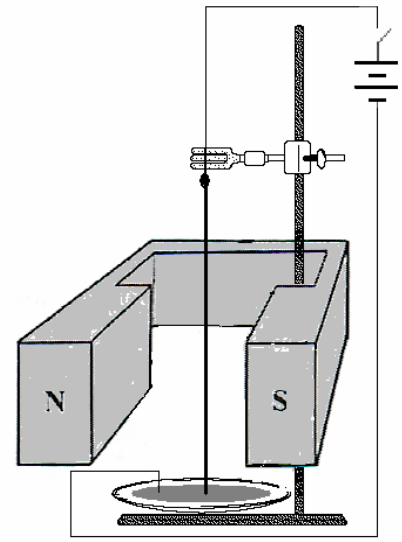


Figure 3

(*m*) Sketch a graph to show the variation of an a.c. voltage with time.

(*n*) What is *nuclear fission*?

(*o*) The following fusion nuclear reaction takes place in the sun:

$$ {}^{2}_{1}\mathbf{H} \quad + \quad {}^{2}_{1}\mathbf{H} \quad \rightarrow \quad {}^{4}_{2}\mathbf{He} \quad + \quad \mathbf{energy} $$

Explain why a large quantity of energy is produced in this reaction. (11 × 6)

2. Define (i) mass, (ii) weight. (6)

State *Newton's law of universal gravitation*. (9)

What is the relationship between G, the gravitational constant, and g, the acceleration due to gravity at the surface of the earth? (6)

A student carried out an experiment to measure the acceleration due to gravity, g.

Draw a labelled diagram of a suitable apparatus.

State what measurements were made and how a value for g was obtained from these measurements. (18)

A child threw a ball vertically up into the air. When the ball fell down it struck the ground.

Ignoring the effect of air resistance, state an energy conversion that occurred:

(iii) as the ball was rising through the air

(iv) as the ball was falling to the ground

(v) as the ball struck the ground. (9)

The ball left the child's hand at a height 1.5 m above the ground and its initial velocity was 7.0 m s^{-1} upwards.

Calculate

(vi) the time taken for the ball to reach its maximum height above the ground

(vii) the maximum height of the ball above the ground

(viii) the maximum kinetic energy of the ball that had a mass of 0.2 kg. (18)

3. (*a*) What is meant by (i) reflection of light, (ii) refraction of light? (9)

(*b*) Draw ray diagrams to show the formation of the image when an object is placed:

(i) inside the focus of a concave mirror

(ii) inside the focus of a converging lens. (18)

(*c*) Describe, in terms of light rays, the difference between a real image and a virtual image. (6)

(*d*) Describe, with the aid of a labelled diagram, an experiment to measure the focal length of a concave mirror. (15)

(*e*) A dentist uses a concave mirror, like that shown in **Figure 4**, to examine a tooth.
The mirror has a focal length of 2.4 cm and is held at a distance of 2.0 cm from the tooth.

Calculate:

(i) the distance between the mirror and the image of the tooth;

(ii) the magnification produced by the mirror. (12)

Figure 4

Figure 5

(*f*) A dentist can also use converging lenses fitted to plane glasses, as shown in **Figure 5**, to produce a magnified image of a tooth. The focal length of each lens is 33 cm and each lens is 28 cm from the tooth.
Describe the image formed. (6)

4. (*a*) A thermometric property, two reference temperatures and a scale are required to measure temperature.
Give an example of a thermometric property. (6)

What are the two reference temperatures used to establish the Celsius scale?
Describe how each of these reference temperatures can be achieved in the laboratory. (12)

The lower reference point on the Kelvin scale is absolute zero.
Explain the underlined term. (6)

(*b*) State *Boyle's law*.
What is an *ideal gas*? (12)

Figure 6 shows an apparatus used to verify Boyle's law. The volume V of the argon gas trapped in the apparatus was measured at different values of pressure P.

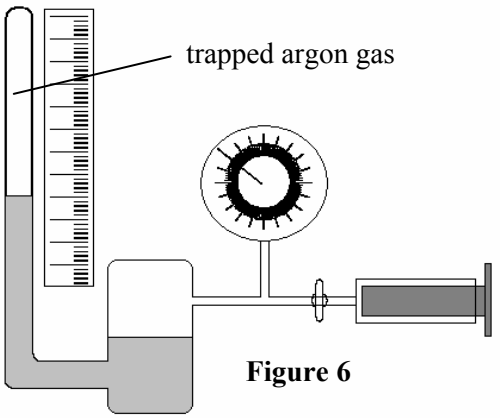


Figure 6

The following data were recorded at room temperature.

P/kPa	101	150	175	200	225	250
V/cm^3	20.0	13.1	11.2	10.2	8.8	8.0

Draw a suitable graph on graph paper to show the relationship between the pressure of the gas and its volume. (12)
Explain how your graph verifies Boyle's law. (6)

Use the slope of your graph to calculate the number of moles of argon gas trapped in the apparatus when the room temperature was 290 K. (12)

[Universal gas constant, R = 8.3 J K^{-1} mol^{-1}]

5. Define *electric current*.
Distinguish between *direct current* and *alternating current*.
State *Ohm's law*. (15)

A mobile phone contains a rechargeable 3.7 V battery that supplies direct current to the phone's electrical circuits.
Calculate:

(i) the effective resistance of the arrangement of resistors in one of the phone's circuits that is shown in **Figure 7**

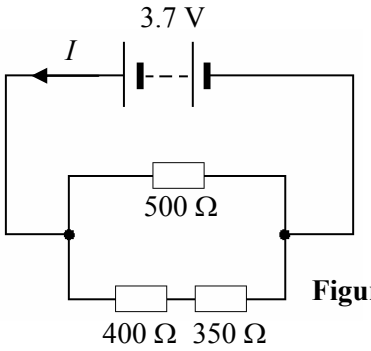


Figure 7

(ii) the current I flowing in this circuit

(iii) the electrical energy used by this circuit in 30 seconds. (21)

The phone's battery can be recharged by connecting the phone to a charger plugged into the mains supply. The charger contains a transformer.

Explain the operation of a transformer. (15)

The transformer in the phone charger has 1200 turns in the primary coil and is connected to the 230 V mains supply.

Calculate the number of turns required in the secondary coil to generate an output of 4.6 V.
How could the transformer be modified to produce a higher output voltage?
Give one way of reducing energy losses in a transformer. (15)

6. Answer any **two** of the following parts (*a*), (*b*), (*c*), (*d*). Each part carries 33 marks.

(*a*) Distinguish between a *vector* and a *scalar*. (6)

Define *momentum*. (6)

State *Newton's third law of motion*. (6)

A tennis ball of mass 0.06 kg, moving horizontally in an easterly direction at 20.0 m s^{-1}, struck a vertical wall and bounced back horizontally at a speed of 15.0 m s^{-1}.

Calculate the change in momentum when the ball bounced off the wall. (9)

Does the *principle of conservation of momentum* apply in this case? Justify your answer. (6)

(*b*) What is meant by (i) the frequency of a wave, (ii) the speed of a wave? (6)

Figure 8 shows a wave of wavelength λ and amplitude A.
State the distance marked **X** in terms of λ and the distance marked **Y** in terms of A. (6)

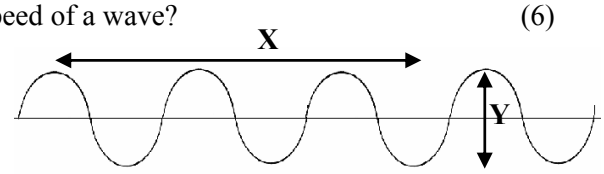


Figure 8

Name the phenomenon that occurs when two waves meet.

Explain, in terms of amplitude what happens when two waves travelling in the same direction meet:
(i) in phase, (ii) completely out of phase. (12)

Plane transverse waves approach a gap in an obstacle as shown in **Figure 9**. Copy the diagram into your answerbook and show on it what happens as the waves go through the gap and into the space beyond the obstacle.

How does the outcome depend on the relationship between λ and the width of the gap? (9)

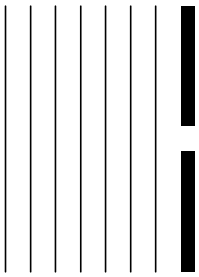


Figure 9

(*c*) To demonstrate the photoelectric effect, a freshly cleaned zinc plate was placed on the cap of a negatively charged gold leaf electroscope and was exposed to different types of electromagnetic radiation.

What is the *photoelectric effect*? (6)

What was observed when infrared radiation was used? Justify your answer. (6)

Describe how the electroscope was charged negatively. (6)

Give one application of the photoelectric effect. (3)

Radiation of wavelength 3.6×10^{-7} m caused the gold leaf to collapse.

Calculate:

(i) the frequency of this radiation

(ii) the energy of a photon of this radiation. (12)

[speed of light, $c = 3.0 \times 10^8$ m s^{-1}; Planck constant, $h = 6.6 \times 10^{-34}$ J s]

(*d*) The radioactive element polonium was discovered in 1898 by Marie Curie. Polonium–209 is its longest-lived isotope and has a half-life of 103 years. It is an alpha particle emitter.

What is an alpha particle?

How far can alpha particles penetrate air? (9)

Write a nuclear equation to represent the decay of a polonium–209 nucleus when it emits an alpha particle. (Refer to *formulae and tables* booklet, p.79.) (12)

The laboratory notebooks used by Marie Curie in 1898 are still contaminated with her radioactive fingerprints. In what year had the radioactivity due to the polonium–209 in the notebooks reduced to half its original level? (6)

Give two precautions that should be taken when working with radioactive substances. (6)

SECTION II – CHEMISTRY (200 marks)

7. Answer **eleven** of the following items (*a*), (*b*), (*c*), etc. All the items carry equal marks.
Keep your answers short.

(*a*) Identify the ion that has ten electrons and thirteen protons.

(*b*) What are isotopes?

(*c*) **Figure 10** shows the bonding in graphite, an allotrope of carbon.
What type of bond holds the carbon atoms together:
(i) within each layer, (ii) between adjacent layers?

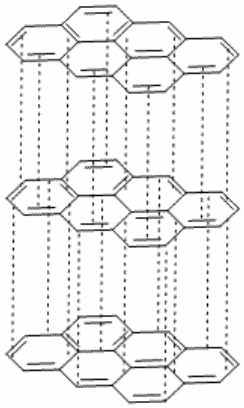


Figure 10

(*d*) What is a mole of a substance?

(*e*) Define the first ionisation energy of a neutral gaseous atom of an element.

(*f*) Distinguish between an *exothermic* reaction and an *endothermic* reaction.

(*g*) Why does sodium chloride conduct electricity in solution but not in the solid state?

(*h*) In the following reaction, what species acts (i) as the acid, (ii) the conjugate acid?

$$HNO_3 + H_2F_2 \rightleftharpoons H_2NO_3^+ + HF_2^-$$

(*i*) Give two properties of anhydrous sodium carbonate that make it suitable for use as a primary standard in acid-base titrations.

(*j*) Give an example of (i) an acidic oxide, (ii) an amphoteric oxide.

(*k*) Define *heat of combustion*.

(*l*) Calculate the percentage of nitrogen by mass in sodium azide (NaN_3), a substance that can be used to inflate air bags in cars.
[N = 14; Na = 23]

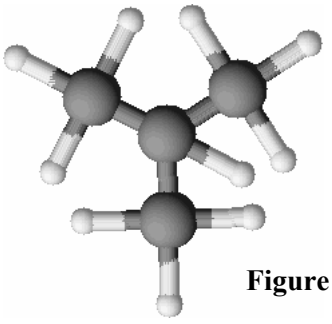


Figure 11

(*m*) Write a balanced chemical equation for the combustion of ethyne (C_2H_2) in excess oxygen.

(*n*) Identify the saturated hydrocarbon depicted in the structure shown in **Figure 11**.

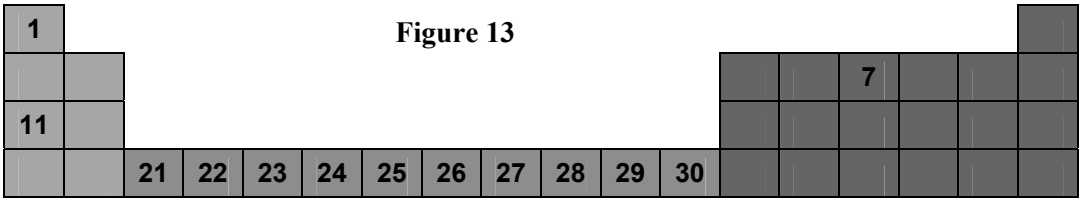
(*o*) Name the organic compounds shown in **Figure 12**.

Figure 12

(11 × 6)

8. **Figure 13** shows the layout of the first thirty-six elements on the Periodic Table of the elements. (Refer to the *formulae and tables* booklet, p.79.)

Figure 13



(*a*) Define (i) atomic number, (ii) mass number, (iii) relative atomic mass. (12)

(*b*) Explain the following terms used in Bohr's model of the hydrogen atom:
(i) *energy level*, (ii) *ground state*, (iii) *excited state*.
What happens when an electron in an excited state in an atom falls to a lower energy state?
Describe how to carry out a flame test on a salt of element 11. (24)

(*c*) Sublevels and atomic orbitals are also important structural features of an atom.
Define the term *atomic orbital*.
Sketch the shape of (i) an *s* atomic orbital, (ii) a *p* atomic orbital.
Give the electron configuration of the element 7 showing the arrangement of the electrons in orbitals. How many sublevels are occupied by these electrons?
What do the electron configurations of elements 21 to 30 have in common? (24)

(*d*) Quantum numbers give information about electrons in atoms. What information about an electron is given by (i) the principal quantum number, (ii) the subsidiary quantum number? (6)

9. Vinegar is an aqueous solution containing **CH_3COOH**, a weak acid. A solution of diluted vinegar was titrated against 20.0 cm^3 portions of a 0.12 M standard solution of potassium hydroxide, which is a strong base, using a suitable indicator. One rough and two accurate titrations were carried out. The following volumes of diluted vinegar were recorded:

22.7 cm^3 **22.4 cm^3** **22.3 cm^3**

The balanced equation for the titration reaction is:

$$CH_3COOH + KOH \rightarrow CH_3COOK + H_2O$$

(*a*) Define (i) a weak acid, (ii) a strong base, according to the Brønsted-Lowry theory.
What is the conjugate base of **CH_3COOH**?
Is this conjugate base weak or strong? Justify your answer. (15)

(*b*) Define pH.
Calculate the pH of the 0.12 M potassium hydroxide solution. (9)

(*c*) Describe the correct procedure for
(i) rinsing a 20 cm^3 pipette for use in this titration
(ii) filling the pipette to the mark
(iii) using the pipette to deliver exactly 20.0 cm^3 to a conical flask. (12)

(*d*) What is an acid-base indicator?
Name a suitable indicator for this titration.
State the colour change observed in the conical flask at the end point of this titration. (15)

(*e*) Calculate the concentration of **CH_3COOH** in the diluted vinegar solution in:
(i) moles per litre
(ii) grams per litre. (15)

[H = 1; C = 12; O = 16]

10. The electrochemical series lists the common metals in order of their decreasing ease of oxidation. Chemical reactions of metals can often be explained by their position in the electrochemical series.

(*a*) Place the metals **iron**, **silver**, **sodium** and **magnesium** in the order they occur in the electrochemical series.

Explain why everyday objects are rarely made of magnesium and never made of sodium. (9)

(*b*) Define in terms of electron transfer (i) *oxidation*, (ii) *reduction*.
Identify (iii) the substance oxidised, (iv) the species that behaves as the reducing agent in the following reaction:

$$\mathbf{3Mg + Fe_2O_3 \rightarrow 3MgO + 2Fe} \quad (12)$$

(*c*) What is observed when small pieces of (i) sodium, (ii) silver, are added to cold water? Write a balanced chemical equation for any reaction that occurs. (12)

(*d*) Explain why a piece of magnesium ribbon wound tightly around an iron key, as shown in **Figure 14**, protects the key from corrosion. (6)

Figure 14

(*e*) A second identical iron key is electroplated with silver to protect it from corrosion using an electrolysis arrangement as shown in **Figure 15**.

What is electrolysis?

State *Faraday's first law of electrolysis*. (12)

Write balanced equations for the reactions at the cathode and at the anode. (6)

A current of 1.93 A is passed through the silver nitrate solution for 2.5 minutes.

Calculate:

(i) the charge that flows
(ii) the mass of silver plated on the key. (9)

[Ag = 108; 1 faraday = 96 485 C]

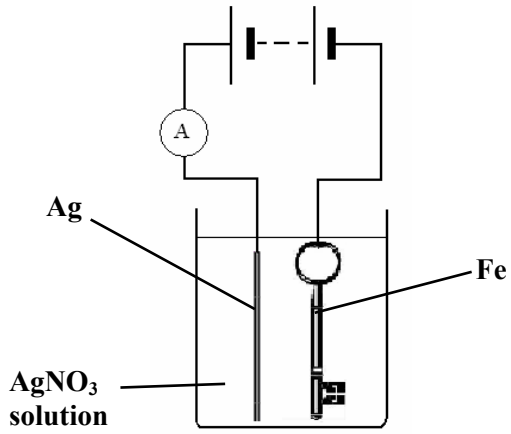


Figure 15

11. Explain each of the following terms: (i) *functional group*, (ii) *homologous series*. (12)

Draw the molecular structures of ethene, ethanol and ethanal. (9)

Name the homologous series to which ethene belongs.

Name and draw the molecular structure of the next member of this series. (9)

Describe, with the aid of a labelled diagram, how you could prepare ethene from ethanol. (12)

Describe a test to show that ethene is unsaturated. (9)

The arrangement shown in **Figure 16** was used to prepare ethanal from ethanol by oxidation and collect it over ice-water.

Name the orange-coloured reagent **A**.

Why is the ethanal distilled off as soon as it is formed?

Why is the collecting flask cooled in ice-water?

A red precipitate formed when a few drops of Fehling's reagent was added to the ethanal product.

What is the purpose of this test? (15)

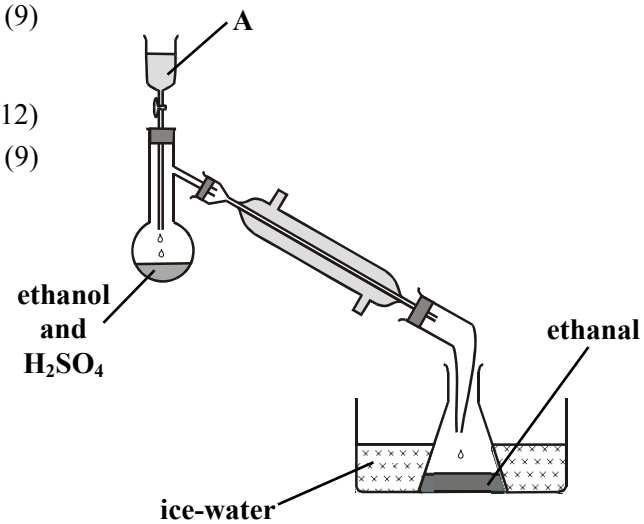


Figure 16

12. Answer any **three** of the following parts (*a*), (*b*), (*c*), (*d*). Each part carries 22 marks.

(*a*) Define *electronegativity*.

Explain the general increase in electronegativity values across a period in the periodic table.

Use electronegativity values to predict the type of bond in the simplest compound of:

(i) magnesium and oxygen
(ii) carbon and hydrogen.

Which of these two compounds occurs in crystalline form?

What type of crystal is formed? (Refer to *formulae and tables* booklet, p.81.)

(*b*) Draw a diagram to show the bonding in a molecule of ammonia.

Use the electron pair repulsion theory to explain:

(i) the shape of an ammonia molecule, (ii) the bond angle in an ammonia molecule.

Does an ammonia molecule have a dipole moment? Justify your answer.

Account for the difference in shape between an ammonia molecule and a boron trifluoride molecule.

(*c*) Air purifying cartridges containing lithium peroxide $\mathbf{Li_2O_2}$ are used in submarines and in spacecraft to absorb the carbon dioxide produced during respiration and to release oxygen. The reaction that occurs is:

$$\mathbf{2Li_2O_2 + 2CO_2 \rightarrow 2Li_2CO_3 + O_2}$$

Calculate

(i) the number of moles of lithium peroxide in a 460 g air purifying cartridge
(ii) the volume of carbon dioxide absorbed by one cartridge, if measured at STP
(iii) the mass of lithium carbonate waste formed when a cartridge is used up
(iv) the number of molecules of oxygen released when one cartridge is used up.

[Li = 7; C = 12; O = 16; molar volume at STP = 22.4 litres; Avogadro constant = 6.0×10^{23} mol^{-1}]

(*d*) State *Hess's law.*

The balanced equation for the preparation of ethyne is:

$$\mathbf{CaC_{2\,(s)} + 2H_2O_{(l)} \rightarrow C_2H_{2\,(g)} + Ca(OH)_{2\,(s)}}$$

Use Hess's law and the heats of formation listed to calculate the heat produced in the preparation of ethyne.

$$\mathbf{2C_{(s)} + H_{2\,(g)} \rightarrow C_2H_{2\,(g)} \qquad \Delta H = 227\ kJ\ mol^{-1}}$$
$$\mathbf{H_{2\,(g)} + \tfrac{1}{2}O_{2\,(g)} \rightarrow H_2O_{(l)} \qquad \Delta H = -286\ kJ\ mol^{-1}}$$
$$\mathbf{Ca_{(s)} + 2C_{(s)} \rightarrow CaC_{2\,(s)} \qquad \Delta H = -60\ kJ\ mol^{-1}}$$
$$\mathbf{Ca_{(s)} + H_{2\,(g)} + O_{2\,(g)} \rightarrow Ca(OH)_{2\,(s)} \qquad \Delta H = -985\ kJ\ mol^{-1}}$$

Ethyne gas is prepared in a school laboratory by adding water to solid calcium carbide and collecting the gas produced over water, as shown in **Figure 17**.

Does the temperature inside the reaction flask increase or decrease as the reaction proceeds? Justify your answer.

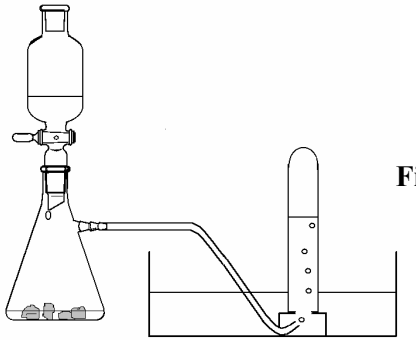


Figure 17

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