Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2012

PHYSICS AND CHEMISTRY – HIGHER LEVEL

MONDAY, 18 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.

N.B. Relevant data are listed in the Formulae and Tables booklet, which is available from the Superintendent.

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 the *principle of conservation of momentum*.

(*c*) Calculate the work done when a crane lifts a 125 kg girder from the ground to a height of 50 m, as shown in **Figure 1**.

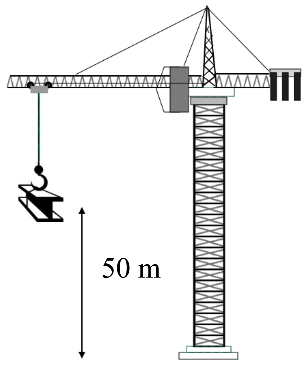

Figure 1

(*d*) When an image of an object is formed, what is meant by *lateral inversion*?

(*e*) The dotted lines in **Figure 2** represent light rays striking three different diamonds, whose shapes are classified as shallow cut, ideal and deep cut. What phenomenon occurs at (i) **A**, (ii) **B**?

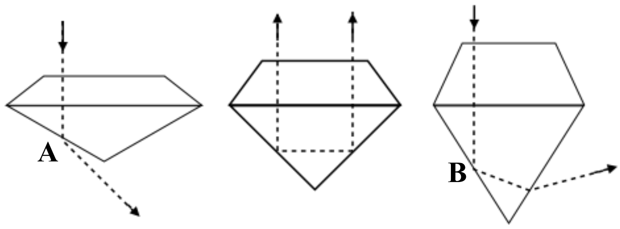

Figure 2

(*f*) List two properties of ultraviolet radiation.

(*g*) What is the *photoelectric effect*?

(*h*) Give two examples of a thermometric property.

(*i*) The equation used to define temperature θ on the Celsius scale is $\dfrac{\theta}{100} = \dfrac{X_\theta - X_0}{X_{100} - X_0}$.

What do X_θ and X_{100} represent?

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

(*k*) Give one use for a capacitor.

(*l*) A student is asked to charge an electroscope positively by induction. A negatively charged rod was brought near the cap of the electroscope as shown in **Figure 3**. What steps must be carried out to complete the process?

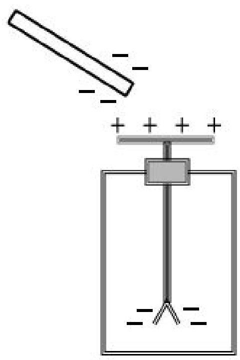

Figure 3

(*m*) Calculate the energy produced when a current of 13 A flows through a piece of fuse wire of resistance 0.1 Ω and melts it in 0.2 s.

(*n*) What is meant by *mass-energy conservation* in nuclear reactions?

(*o*) What conditions are required for a nuclear fusion reaction to occur?

(11 × 6)

2. Define (i) kinetic energy, (ii) power. (12)

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

How is the unit of force, the newton, derived from Newton's second law of motion? (6)

A student carried out an experiment to show that the acceleration of an object is directly proportional to the force applied.

Draw a labelled diagram of a suitable apparatus.

State what measurements were made and how the relationship between acceleration and the applied force was established. (18)

The driver of a Formula 1 racing car of laden mass 640 kg was travelling at 75 m s^{-1} along a straight, horizontal stretch of a racing circuit, as shown in **Figure 4**. The driver applied the brakes over the last 25 m to reduce the speed to 60 m s^{-1} to negotiate the next bend of the circuit.

Calculate

- (i) the acceleration of the car approaching the bend
- (ii) the time spent braking
- (iii) the force applied by the brakes
- (iv) the power generated during braking. (21)

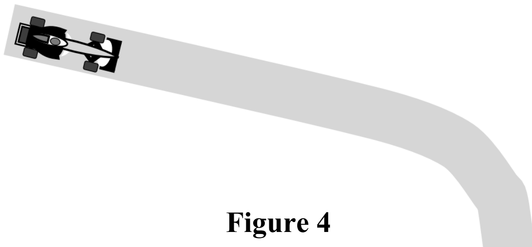

Figure 4

What energy conversion takes placed during braking? (3)

3. (*a*) State the *laws of refraction of light*. (12)

(*b*) In terms of light rays, distinguish between a real image and a virtual image. (6)

(*c*) Describe, with the aid of a labelled diagram, an experiment to measure the focal length of a convex (converging) lens. (15)

(*d*) An object is placed 30 cm in front of a convex lens of focal length 12 cm.

Calculate

- (i) the distance of the image of this object from the lens
- (ii) the magnification of the image relative to the object. (12)

(*e*) Draw a diagram to show the formation of an image in a convex lens when it is used as a simple microscope (magnifying glass). (9)

(*f*) A compound microscope consists of two convex lenses **A** and **B** of focal lengths f_A and f_B, respectively. An object **O** is placed just outside the focus of the objective lens **A** and its image **I** is formed at the focus of the eyepiece lens **B** as shown in **Figure 5**.

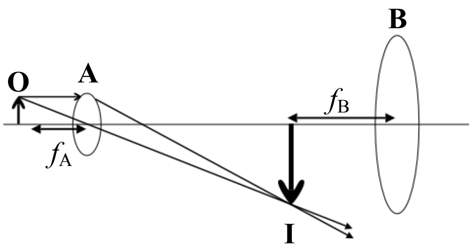

Figure 5

Copy the diagram into your answerbook and show the formation of the final image by the eyepiece lens **B**.

Describe the final image. (12)

4. The gas laws describe the various relationships between the pressure, volume and temperature of a fixed mass of gas.

State *Boyle's law.* (6)

Describe, with the aid of a labelled diagram, an experiment to verify Boyle's law. (18)

Distinguish between a real gas and an ideal gas. (6)

Under what conditions of (i) temperature, (ii) pressure, does a real gas behave like an ideal gas? Justify your answers. (12)

In **Figure 6** the lines **A** and **B** show the experimental relationship between the volume V and the temperature θ on the Celsius scale for the same fixed mass of oxygen gas at two different pressures, $P_1 = 4.04 \times 10^5$ Pa and P_2, respectively.

Line **C** represents the theoretical relationship between volume and temperature of a fixed mass of an ideal gas.

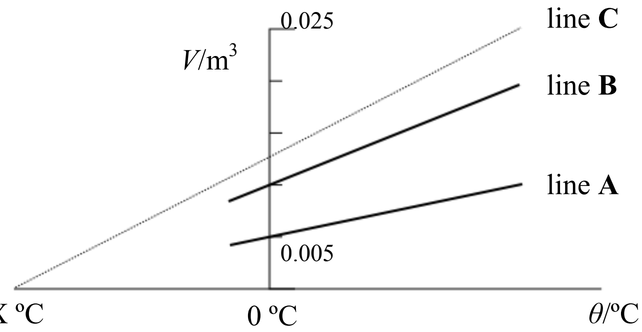

Figure 6

Using the value of P_1 and the data provided in **Figure 6**,

(i) calculate the number of moles of oxygen gas in the sample

(ii) deduce the value of P_2

(iii) state the value of X. (18)

Describe the significance of the point (X, 0) on the graph. (6)

5. State *Ohm's law.*

Define the *ampere,* the SI unit of current. (15)

The circuit shown in **Figure 7** was used to investigate Ohm's law for a metallic conductor. The current I through the conductor was measured for different values of the potential difference V across it.

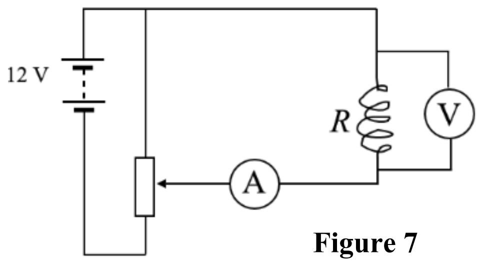

Figure 7

The following data were recorded.

V/V	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
I/A	0.08	0.17	0.25	0.33	0.42	0.47	0.50	0.51

(i) Using the data, draw a suitable graph to show the relationship between potential difference V and current I for the conductor. (15)

(ii) Explain why the graph verifies Ohm's law for this conductor at low currents ($I < 0.4$ A), but not at higher currents ($I > 0.4$ A). (6)

(iii) Suggest a reason why the conductor only obeys Ohm's law when the current I flowing through it is small. (3)

(iv) Use your graph to calculate the resistance R of the metallic conductor at low currents. (6)

Figure 8 shows a moving coil galvanometer.

(v) What is the principle of operation of a moving coil galvanometer? (9)

(vi) What is the purpose of the restoring spring? (3)

(vii) Explain how a resistor, called a shunt, is used to convert a moving coil galvanometer to an ammeter. (9)

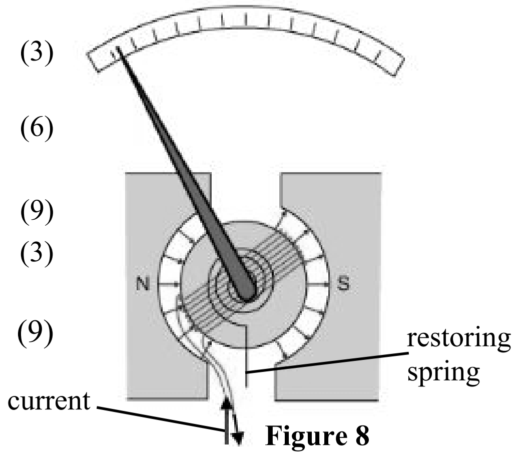

Figure 8

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

(*a*) State *Newton's law of gravitation.* (6)

Describe an experiment to measure to acceleration due to gravity, *g*. (18)

Calculate the gravitational force between two objects, each of mass 5.0 kg, when the distance between them is 0.25 m on a horizontal table. (6)

Explain why this gravitational force does not cause the two spheres to move towards each other. (3)

(*b*) What is meant by *interference* of waves?

Distinguish between constructive interference and destructive interference. (9)

Describe, with the aid of a labelled diagram, how you would demonstrate an interference pattern, using a monochromatic light source. (9)

Calculate the energy of a photon of <u>monochromatic light</u> of wavelength 589 nm. (12)

Explain the underlined term. (3)

(*c*) State *Faraday's law of electromagnetic induction*. (6)

Describe the behaviour of the electrons in a conductor carrying
(i) a direct current (d.c.)
(ii) an alternating current (a.c.). (6)

Describe, with the aid of a labelled diagram, how a transformer works. (12)

Give one way of reducing energy losses in a transformer. (3)

In Ireland, the mains voltage is supplied at 230 V a.c. and in the United States of America the mains voltage is 110 V a.c.

A travel voltage adaptor purchased in Ireland for use in the United States of America, shown in **Figure 9**, contains a transformer designed to change a 110 V supply to a 230 V supply.

If the primary coil of the transformer has 46 turns, how many turns in the secondary coil? (6)

Figure 9

(*d*) The Japanese nuclear accident in March 2011 released the radioisotopes iodine–131 and caesium–137, both beta particle emitters, into the environment. The half-life of iodine–131 is 8 days, the half-life of caesium–137 is 30 days. These leaked isotopes had been produced in the nuclear reactors by the nuclear fission of the uranium–235 fuel.

(i) What is nuclear fission? (3)

(ii) Give two properties of beta particles. (6)

(iii) Why is there concern about the release of these fission products into the environment? (3)

(iv) Why is there more concern about the caesium–137 than the iodine–131? (3)

(v) What fraction of the iodine–131, that leaked on a particular day, would remain 32 days later? (9)

(vi) Write a nuclear equation for the decay of an iodine–131 nucleus when it emits a beta particle. (9)

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*) How many (i) neutrons, (ii) electrons, are there in the $^{9}_{4}Be^{2+}$ ion?

(*b*) Define the *first ionisation energy* of a mole of neutral gaseous atoms.

(*c*) The crystal structure of diamond is shown in **Figure 10**.
Explain, in terms of bonding, why diamond is difficult to cut.

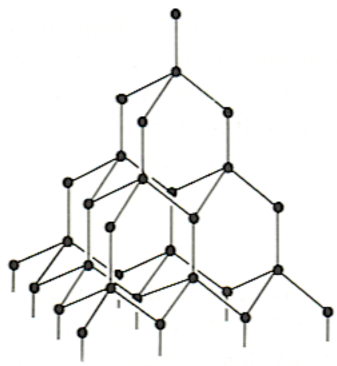

Figure 10

(*d*) What do the terms E_2 and f represent in the equation $E_2 - E_1 = hf$?

(*e*) How many molecules are there in 672 cm^3 of carbon monoxide gas when measured at STP?

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

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

(*h*) Calculate the pH of a 0.05 M solution of potassium hydroxide.

(*i*) Write a balanced chemical equation for the vigorous reaction that occurs between sodium and water.

(*j*) Give a major use for (i) sulfur dioxide, (ii) hydrogen peroxide.

(*k*) Balance this chemical equation:

$$\mathbf{Fe_2O_3 + CO \rightarrow Fe + CO_2}$$

(*l*) Calculate the percentage of chlorine by mass in a rat poison containing barium chloride (**$BaCl_2$**).

(*m*) Draw the structure of an isomer of 2-methylpropane.

(*n*) A mixture of one mole of methane and one mole of chlorine is exposed to sunlight. Write the equation for this reaction.

(*o*) When an organic compound and phenylhydrazine was heated gently in a test tube as shown in **Figure 11**, an orange precipitate appeared.
This result confirms the presence of a *carbonyl* group in the organic compound.
Draw the structure of the carbonyl group.

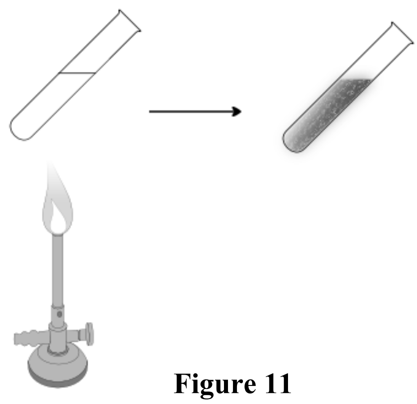

Figure 11

(11 × 6)

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

(*b*) Naturally occurring copper is composed of 69.15% ${}^{63}_{29}Cu$ and 30.85% ${}^{65}_{29}Cu$.
Calculate the relative atomic mass of copper, correct to two decimal places.

Describe the bonding in copper metal.

Copper is a transition metal. Give one characteristic property of a transition metal. (18)

(*c*) Define *electronegativity*.

Use electronegativity values to predict the type of bonding in a molecule of ammonia (**NH_3**).

Draw a diagram to show the bonding in a molecule of ammonia.

Use electron pair repulsion theory to predict the shape and bond angle in a molecule of ammonia.

Why does a molecule of ammonia have a dipole moment? (27)

(*d*) Identify the type of intermolecular bonding that occurs in ice as represented by the dotted lines in **Figure 12**.
Give a property of liquid water that is associated with this type of intermolecular bonding.

What happens to these intermolecular bonds when water boils? (9)

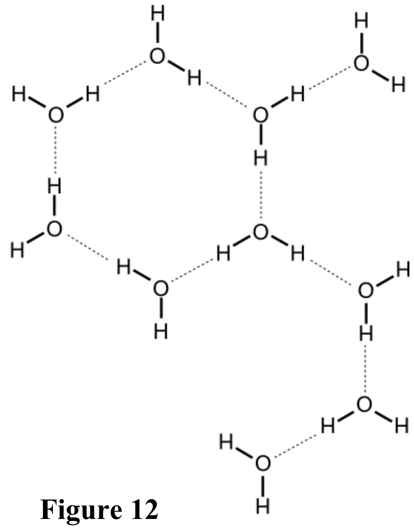

Figure 12

9. Overproduction of hydrochloric acid in the human stomach can cause discomfort known as ‘indigestion’ or ‘heartburn’. This can be relieved by swallowing a basic substance or ‘antacid’. Sodium hydrogencarbonate (bread soda) is sometimes used as an antacid.

A solution of sodium hydrogencarbonate was titrated with a <u>standard solution</u> of hydrochloric acid to determine the concentration of the sodium hydrogencarbonate solution.

The balanced equation for the titration reaction is:

$$\mathbf{HCl + NaHCO_3 \rightarrow NaCl + H_2O + CO_2}$$

A few drops of methyl orange indicator were added to a conical flask containing a 25 cm^3 portion of the sodium hydrogencarbonate solution before commencing the titration. On average, the sodium hydrogencarbonate solution required 21.4 cm^3 of the 0.12 M hydrochloric acid solution for neutralisation.

(*a*) Explain the underlined term above. (3)

(*b*) Describe the procedure for rinsing, filling and using a pipette to deliver exactly 25 cm^3 of the sodium hydrogencarbonate solution. (18)

(*c*) Two operations were carried out on the conical flask during the titration.
What were these operations and what was the purpose of each one? (12)

(*d*) Why was it important **not** to use tap-water in the experiment? (6)

(*e*) State the colour change observed in the conical flask at the end point.
Explain why methyl orange was a suitable indicator for this titration. (9)

(*f*) Calculate the concentration of the sodium hydrogencarbonate solution in
(i) moles per litre
(ii) grams per litre. (12)

(*g*) What volume of stomach acid of concentration 0.12 M is neutralised by drinking 50 cm^3 of a bread soda solution of the same concentration as the sodium hydrogencarbonate solution used in this titration? (6)

10. Magnesium is a strong metal of low density, used with aluminium in the manufacture of lightweight alloys in the aerospace and automobile industries.
Magnesium occurs in seawater in the form of its salts, e.g. MgO and $MgCl_2$.

(*a*) Why does magnesium metal **not** occur free in nature? (3)

(*b*) Compare the reactivities of magnesium, silver and aluminium with water. (9)

(*c*) Define (i) oxidation, (ii) reduction, in terms of electron transfer.

Magnesium metal is extracted from magnesium oxide at high temperatures in this reaction:

$$\mathbf{2MgO \quad + \quad Si \quad \rightarrow \quad 2Mg \quad + \quad SiO_2}$$

Identify (i) the substance reduced, (ii) the species that behaves as the reducing agent.

How do pieces of magnesium metal, that are attached to underground pipes or underwater structures made of iron or steel, protect these objects from corrosion? (15)

(*d*) Magnesium metal can also be extracted by the electrolysis of molten magnesium chloride using inert electrodes as shown in **Figure 13**.

What is electrolysis?

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

Write balanced equations for the reactions at the cathode and at the anode.

Why must the magnesium chloride be molten? (15)

A current of 90 000 A is passed through the molten magnesium chloride for 30 seconds.

Calculate

(i) the charge that flows
(ii) the mass of magnesium produced. (12)

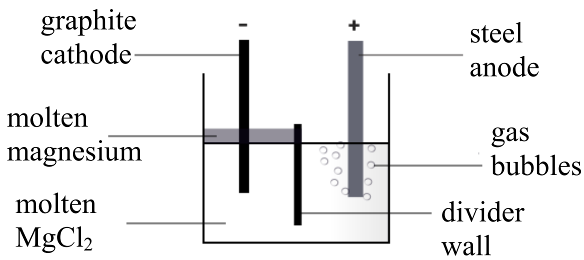

Figure 13

11. **Figure 14** shows how a number of useful organic compounds can be inter-converted.

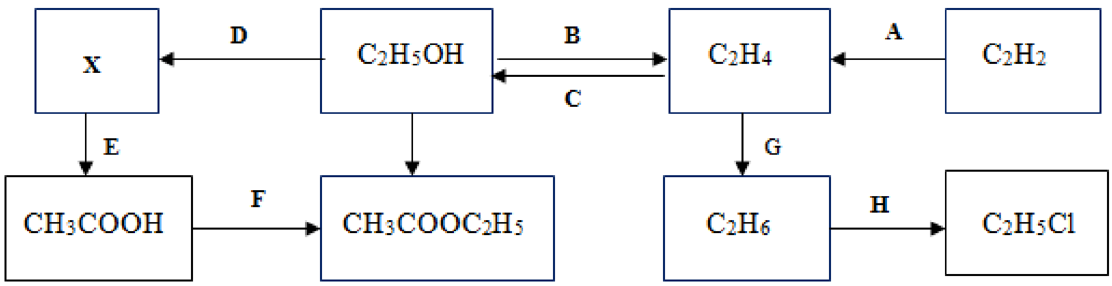

Figure 14

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

(*b*) Ethanol is a good fuel and an important industrial solvent.
Name the homologous series to which ethanol belongs. (3)

(*c*) Ethane, a saturated <u>hydrocarbon</u>, is a good fuel, but most ethane produced is converted into ethene, an <u>unsaturated hydrocarbon</u>. Explain the underlined terms. (12)

(*d*) Give a major use for (i) ethene, (ii) ethanoic acid. (6)

(*e*) Name the reagent used for conversion **B** in a school laboratory. (3)

(*f*) Identify the functional group in compound **X**. (3)

(*g*) Identify (i) an addition, (ii) a substitution, (iii) an oxidation, reaction in **Figure 14**. (9)

(*h*) Describe, with the aid of a labelled diagram, an experiment to prepare ethyne, the gas used as the fuel in oxyacetylene welding. (12)

(*i*) Name and draw the structural formula of $\mathbf{CH_3COOC_2H_5}$ that can be used as a solvent to decaffeinate coffee or to remove nail polish. (6)

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

(*a*) Define (i) an atomic *energy level*, (ii) an atomic *orbital*.

Identify the type of atomic orbital shown in **Figure 15**.

Write the electron configuration (*s*, *p*) of an atom of phosphorus.

How many atomic orbitals are occupied by electrons in an atom of phosphorus in its ground state?

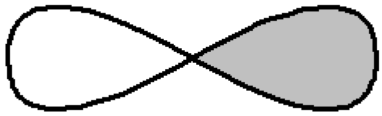

Figure 15

(*b*) Define (i) *acid*, (ii) *conjugate pair*, according to Brønsted-Lowry theory.

Distinguish between a strong acid and a weak acid using this theory.

Identify a conjugate pair and a species acting as a base in the following reaction.

$$\mathbf{H_2SO_4 + HCN \rightleftharpoons HSO_4^- + H_2CN^+}$$

(*c*) Define the *mole*, the SI unit for the amount of a substance.

The amphoteric compound aluminium oxide reacts with hydrochloric acid according to the following balanced equation.

$$\mathbf{Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O}$$

When 10.2 g of aluminium oxide reacted with hydrochloric acid, calculate

(i) the number of moles of aluminium oxide used

(ii) the number of moles of water formed

(iii) the mass of aluminium chloride formed in this reaction.

What is meant by the term *amphoteric*?

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

In the petrochemical industry, heptane $\mathbf{C_7H_{16}}$ is converted into the aromatic hydrocarbon $\mathbf{C_7H_8}$ according to the following balanced equation.

$$\mathbf{C_7H_{16\,(l)} \rightarrow C_7H_{8\,(l)} + 4H_{2\,(g)}}$$

Use Hess's law and the heats of reaction listed below to calculate the heat change for this reaction.

$$\mathbf{C_7H_{16\,(l)} + 11\,O_{2\,(g)} \rightarrow 7\,CO_{2\,(g)} + 8\,H_2O_{(l)} \qquad \Delta H = -4854.9\ kJ\ mol^{-1}}$$

$$\mathbf{C_7H_{8\,(l)} + 9\,O_{2\,(g)} \rightarrow 7\,CO_{2\,(g)} + 4\,H_2O_{(l)} \qquad \Delta H = -3949.0\ kJ\ mol^{-1}}$$

$$\mathbf{H_{2\,(g)} + \tfrac{1}{2}O_{2\,(g)} \rightarrow H_2O_{(l)} \qquad \Delta H = -286.0\ kJ\ mol^{-1}}$$

The structure of a molecule of the aromatic hydrocarbon $\mathbf{C_7H_8}$ is shown in **Figure 16**. Name this compound.

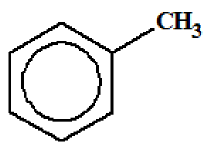

Figure 16

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