(*b*) Explain what is meant by the statement that the paraffin hydrocarbons are members of a homologous series.

(*c*) Ethylene is typical of a group of hydrocarbons which show considerable chemical reactivity. Illustrate this statement by listing *four* different reactions of ethylene.

(*d*) Give an equation for the hydrogenation of olein to stearin. Discuss the commercial significance of this and similar reactions.

(*e*) Give appropriate explanations or interpretations of the following experimental observations:

A starch "solution" was prepared by stirring together powdered starch and a small amount of cold water and then adding a larger volume of boiling water. The solution never appeared clear, but retained a hazy or milky appearance, especially when viewed against a dark background. A portion of the solution gave no reaction with Fehling's solution. Another portion was boiled with a few ml. of concentrated hydrochloric acid. This boiled solution was then optically clear, and yielded a red precipitate when tested with Fehling's solution.

Department of Education, Ontario

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GRADE 13

CHEMISTRY

1. (*a*) For each of the following oxides give (i) the chemical formula, (ii) the physical state (solid, liquid, or gas), and (iii) the solubility in water:

calcium oxide; nitric oxide; lead oxide; silicon dioxide; phosphorus pentoxide.

(*b*) State whether each oxide in part (*a*) is classified as acidic, basic, or neutral.

(*c*) What is meant by the term *amphoteric oxide*? Give an example.

2. The equation for the reaction of potassium permanganate with oxalic and sulphuric acids is as follows:

$$2\,KMnO_4 + 5\,H_2C_2O_4 + 3\,H_2SO_4 \rightarrow 10\,CO_2 + 2\,MnSO_4 + K_2SO_4 + 8\,H_2O.$$

(*a*) Select the elements in this reaction that undergo oxidation or reduction; derive their oxidation numbers before and after reaction, and indicate clearly which is the element oxidized and which reduced.

(*b*) Which compound is the oxidizing agent and which the reducing agent in this reaction?

(*c*) The reaction described by the above equation does not take place instantaneously, and a measure of its "rate" is given by the time required to decolourize a given amount of potassium permanganate solution. Describe (in tabular form if you wish) experiments which show the influence of temperature, concentration of reagents, and catalysis on this rate.

3. (*a*) A stoppered bottle containing a few crystals of iodine is seen to acquire a certain intensity of purple colour in the space above the iodine during prolonged standing at room temperature. Given that the purple colour is that of iodine vapour, account for its constant intensity at constant temperature in terms of a dynamic equilibrium involving the solid and gaseous element.

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(*b*) The intensity of the purple colour in part (*a*) is increased by increasing the temperature of the bottle and its contents. Apply Le Chatelier's principle to deduce whether the vaporization of iodine is accompanied by absorption or evolution of heat.

(*c*) Describe how reasonably pure iodine crystals may be prepared from potassium iodide and any other necessary reagents. Give an equation for the reaction proposed.

4. (*a*) Briefly describe the various radiations emitted from a radioactive mineral such as pitchblende.

(*b*) The element boron (B), having atomic number 5, possesses two stable isotopes of mass numbers 10 and 11. Deduce the number of protons, neutrons, and electrons in an atom of each of these isotopes of boron.

(*c*) Draw a schematic diagram to show the arrangement of the nucleus and the electrons in a boron atom. (In this case the difference in the isotopes may be disregarded.)

(*d*) From the evidence given in this question deduce the valence of boron, and apply this deduction to write the formulas of its oxide and its chloride.

(*e*) Given that the two isotopes of boron mentioned in (*b*) are the only known stable isotopes, and that the chemical atomic weight of boron is 10.8, calculate the relative abundance of these isotopes as they occur in nature.

5. (*a*) Describe practical or commercial uses, *one* for each, for the following compounds, and for each use state a property of the substance on which the use depends:

zinc sulphide; aluminium sulphate; trisodium phosphate; calcium sulphate hydrate.

(*b*) Give an account, including a description of the appearance and any other striking sensory effect, of reactants and products, of the following reactions:

(i) the dissolving of copper in hot, concentrated sulphuric acid;
(ii) the dissolving of copper in concentrated nitric acid;
(iii) the dissolving of aluminium in concentrated sodium hydroxide solution.

(*c*) Give balanced chemical equations for any *two* of the reactions mentioned in part (*b*).

6. (*a*) A chemist proposed to make up a solution of sodium carbonate from the following recipe:

25 grams of sodium carbonate decahydrate ($Na_2CO_3.10H_2O$) plus 75 grams of water.

He then found he had available only anhydrous sodium carbonate, and so decided to prepare an identical solution from this salt. Obtain by calculation the recipe necessary to prepare the same quantity of the solution.

(*b*) Calculate the weight and volume of 20 per cent (by weight) hydrochloric acid, of density 1.10 g./ml., which would just neutralize the sodium carbonate solution of part (*a*), according to the equation

$$Na_2CO_3 + 2\ HCl \rightarrow H_2O + CO_2 + 2\ NaCl.$$

(*c*) Calculate the molarity of the hydrochloric acid of part (*b*).

(*d*) Explain why the sodium carbonate solution of part (*a*), when treated with an indicator such as litmus or phenolphthalein, gives an alkaline reaction.

[Na=23.0, C=12.0, O=16.0, H=1.0, Cl=35.5]

7. (*a*) Describe an experiment, including observations and conclusions, in which an aqueous solution of copper chloride is electrolysed by a direct current between carbon electrodes.

(*b*) Give a brief account of the commercial application of electrolysis to the refining of copper.

(*c*) What is an emulsifying agent? Describe an experiment to show the action of an emulsifying agent.

(*d*) Describe, and explain the action of, a Cottrell precipitator.

(*e*) Saturated solutions of potassium chloride in water have the following compositions at the stated temperatures:

25.5% potassium chloride by weight at 20°C, and
30.0% potassium chloride by weight at 50°C.

Calculate how many grams of potassium chloride should crystallize when 1 kilogram of solution saturated at 50°C. is allowed to cool to 20°C.

8. (*a*) Write structural formulas for the following compounds:

ethane, ethyl alcohol, acetic acid, acetaldehyde, ethylene glycol, ethylene.

[OVER]