Base your answers to questions 57 and 58 on the information below.

Heat is added to a sample of liquid water, starting at 80.°C, until the entire sample is a gas at 120.°C. This process, occurring at standard pressure, is represented by the balanced equation below.

$$H_2O(\ell) + heat \rightarrow H_2O(g)$$

57 In the box *in your answer booklet*, using the key, draw a particle diagram to represent *at least five* molecules of the product of this physical change at 120.°C.   [2]

58 On the diagram *in your answer booklet*, complete the heating curve for this physical change.   [1]

Base your answers to questions 59 and 60 on the information below.

In the gold foil experiment, a thin sheet of gold was bombarded with alpha particles. Almost all the alpha particles passed straight through the foil. Only a few alpha particles were deflected from their original paths.

59 State *one* conclusion about atomic structure based on the observation that almost all alpha particles passed straight through the foil.   [1]

60 Explain, in terms of charged particles, why some of the alpha particles were deflected.   [1]

Base your answers to questions 61 through 63 on the information below.

Some Properties of Three Compounds at Standard Pressure

Compound	Boiling Point (°C)	Solubility in 100. Grams of H_2O at 20.°C (g)
ammonia	−33.2	56
methane	−161.5	0.002
hydrogen chloride	−84.9	72

61 Convert the boiling point of hydrogen chloride at standard pressure to kelvins.   [1]

62 Explain, in terms of molecular polarity, why hydrogen chloride is more soluble than methane in water at 20.°C and standard pressure.   [1]

63 Explain, in terms of intermolecular forces, why ammonia has a higher boiling point than the other compounds in the table.   [1]
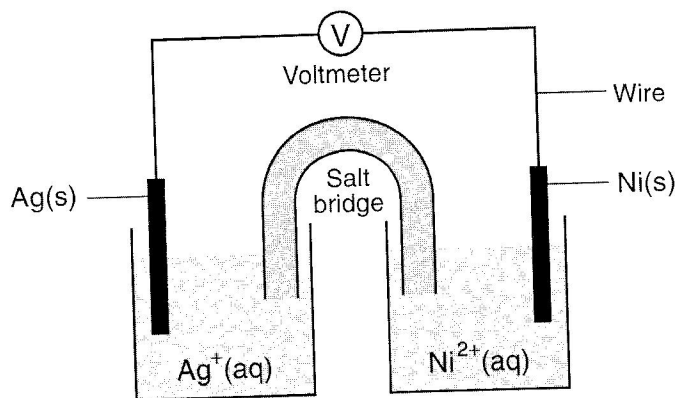
Part C

Answer all questions in this part.

Directions (64–81): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 64 through 66 on the information below.

The diagram below represents an operating voltaic cell at 298 K and 1.0 atmosphere in a laboratory investigation. The reaction occurring in the cell is represented by the balanced ionic equation below.

$$2Ag^+(aq) + Ni(s) \longrightarrow 2Ag(s) + Ni^{2+}(aq)$$

64 Identify the anode in this cell. [1]

65 Determine the total number of moles of $Ni^{2+}(aq)$ ions produced when 4.0 moles of $Ag^+(aq)$ ions completely react in this cell. [1]

66 Write a balanced half-reaction equation for the reduction that occurs in this cell. [1]

Base your answers to questions 75 through 78 on the information below.

In one trial of an investigation, 50.0 milliliters of HCl(aq) of an unknown concentration is titrated with 0.10 M NaOH(aq). During the titration, the total volume of NaOH(aq) added and the corresponding pH value of the reaction mixture are measured and recorded in the table below.
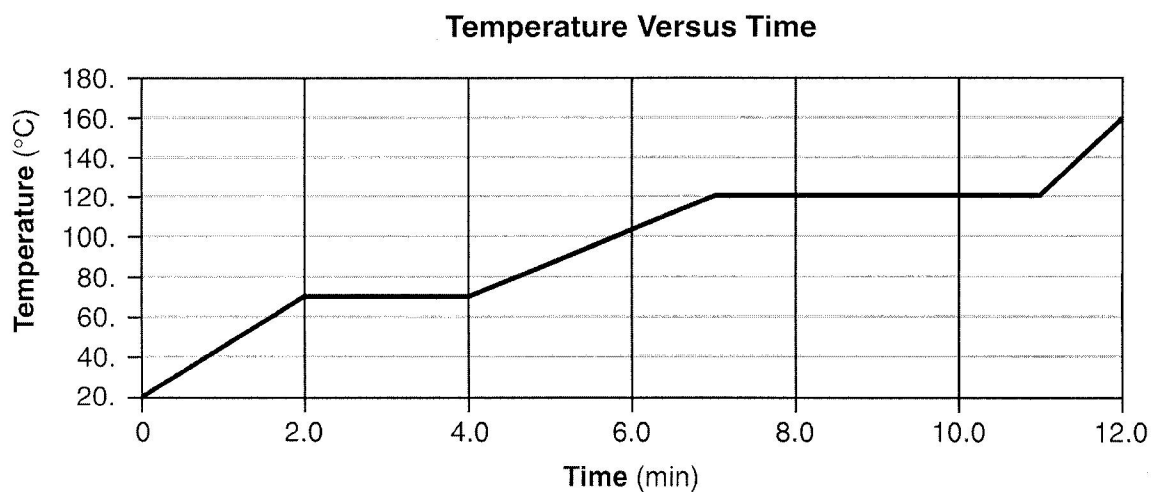
Titration Data

Total Volume of NaOH(aq) Added (mL)	pH Value of Reaction Mixture
10.0	1.6
20.0	2.2
24.0	2.9
24.9	3.9
25.1	10.1
26.0	11.1
30.0	11.8

75 On the grid *in your answer booklet*, plot the data from the table. Circle and connect the points. [1]

76 Determine the total volume of NaOH(aq) added when the reaction mixture has a pH value of 7.0. [1]

77 Write a balanced equation that represents this neutralization reaction. [1]

78 In another trial, 40.0 milliliters of HCl(aq) is completely neutralized by 20.0 milliliters of this 0.10 M NaOH(aq). Calculate the molarity of the titrated acid in this trial. Your response must include *both* a numerical setup and the calculated result. [2]
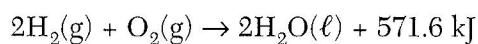
Base your answers to questions 57 through 60 on the information below.

The temperature of a sample of a substance is increased from 20.°C to 160.°C as the sample absorbs heat at a constant rate of 15 kilojoules per minute at standard pressure. The graph below represents the relationship between temperature and time as the sample is heated.

Temperature Versus Time

57 What is the boiling point of this sample? [1]

58 *In your answer booklet,* use the key to draw *at least nine* particles in the box, showing the correct particle arrangement of this sample during the first minute of heating. [1]

59 What is the total time this sample is in the liquid phase, only? [1]

60 Determine the total amount of heat required to completely melt this sample at its melting point. [1]

Base your answers to questions 61 through 63 on the reaction represented by the balanced equation below.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell) + 571.6 \text{ kJ}$$

61 Identify the information in this equation that indicates the reaction is exothermic. [1]

62 On the axes *in your answer booklet,* draw a potential energy diagram for the reaction represented by this equation. [1]

63 Explain why the entropy of the system *decreases* as the reaction proceeds. [1]

Part C

Answer all questions in this part.

Directions (67–84): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry.*
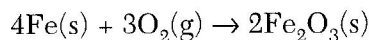
Base your answers to questions 67 through 69 on the information below.

Elements with atomic numbers 112 and 114 have been produced and their IUPAC names are pending approval. However, an element that would be put between these two elements on the Periodic Table has not yet been produced. If produced, this element will be identified by the symbol Uut until an IUPAC name is approved.

67 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for an atom of Uut. [1]

68 Determine the charge of an Uut nucleus. Your response must include *both* the numerical value and the sign of the charge. [1]

69 Identify *one* element that would be chemically similar to Uut. [1]

Base your answers to questions 70 through 72 on the information below.

Rust on an automobile door contains $Fe_2O_3(s)$. The balanced equation representing one of the reactions between iron in the door of the automobile and oxygen in the atmosphere is given below.

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

70 Identify the type of chemical reaction represented by this equation. [1]

71 Determine the gram-formula mass of the product of this reaction. [1]

72 Write the IUPAC name for Fe_2O_3. [1]

Part C

Answer all questions in this part.

Directions (67–84): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry.*
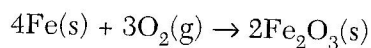
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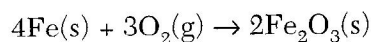
67 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for an atom of Uut. [1]

68 Determine the charge of an Uut nucleus. Your response must include *both* the numerical value and the sign of the charge. [1]

69 Identify *one* element that would be chemically similar to Uut. [1]

Base your answers to questions 70 through 72 on the information below.

Rust on an automobile door contains $Fe_2O_3(s)$. The balanced equation representing one of the reactions between iron in the door of the automobile and oxygen in the atmosphere is given below.

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

70 Identify the type of chemical reaction represented by this equation. [1]

71 Determine the gram-formula mass of the product of this reaction. [1]

72 Write the IUPAC name for Fe_2O_3. [1]

Base your answers to questions 76 and 77 on the information below.

The equilibrium equation below is related to the manufacture of a bleaching solution. In this equation, $Cl^-(aq)$ means that chloride ions are surrounded by water molecules.

$$Cl_2(g) + 2OH^-(aq) \rightleftharpoons OCl^-(aq) + Cl^-(aq) + H_2O(\ell)$$

76 *In your answer booklet*, use the key to draw *two* water molecules in the box, showing the correct orientation of each water molecule toward the chloride ion.   [1]

77 Explain, in terms of collision theory, why increasing the concentration of $Cl_2(g)$ increases the concentration of $OCl^-(aq)$ in this equilibrium system.   [1]

___

Base your answers to questions 78 through 80 on the information below.

In a laboratory activity, 0.500 mole of $NaOH(s)$ is completely dissolved in distilled water to form 400. milliliters of $NaOH(aq)$. This solution is then used to titrate a solution of $HNO_3(aq)$.

78 Identify the negative ion produced when the $NaOH(s)$ is dissolved in distilled water.   [1]

79 In the space *in your answer booklet*, calculate the molarity of the $NaOH(aq)$. Your response must include *both* a correct numerical setup and the calculated result.   [2]

80 *In your answer booklet*, complete the equation representing this titration reaction by writing the formulas of the products.   [1]

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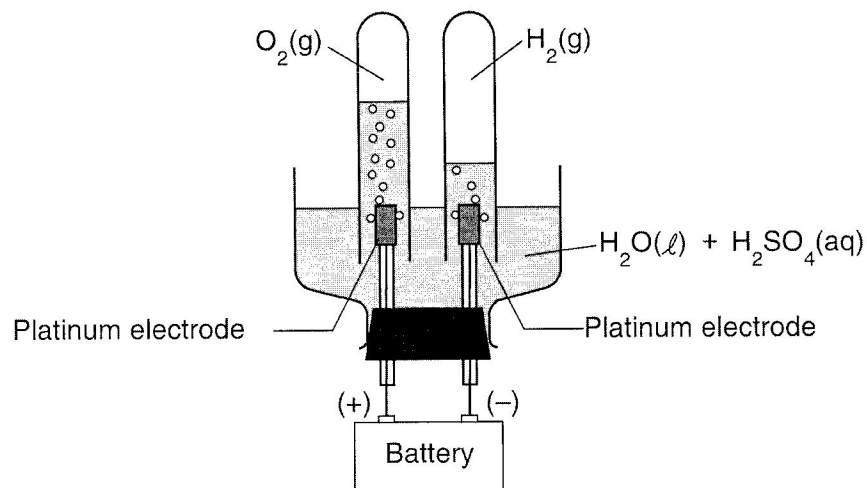Base your answers to questions 81 and 82 on the information below.

The fossilized remains of a plant were found at a construction site. The fossilized remains contain $\frac{1}{16}$ the amount of carbon-14 that is present in a living plant.

81 Determine the approximate age of these fossilized remains.   [1]

82 Complete the nuclear equation *in your answer booklet* for the decay of C-14. Your response must include the atomic number, the mass number, and the symbol of the missing particle.   [1]

___

Base your answers to questions 84 and 85 on the information and diagram below.

The apparatus shown in the diagram consists of two inert platinum electrodes immersed in water. A small amount of an electrolyte, H_2SO_4, must be added to the water for the reaction to take place. The electrodes are connected to a source that supplies electricity.
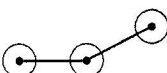

84 What type of electrochemical cell is shown? [1]

85 What particles are provided by the electrolyte that allow an electric current to flow? [1]

Base your answers to questions 78 through 80 on the data in Reference Table S.

78 On the data table *in your answer booklet,* record the boiling points for He, Ne, Ar, Kr, and Xe. [1]

79 On the grid *in your answer booklet,* plot the boiling point versus the atomic number for He, Ne, Ar, Kr, and Xe. Circle and connect the points. [1]

Example:

80 Based on your graph, describe the trend in the boiling points of these elements as the atomic number increases. [1]
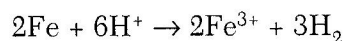
Base your answers to questions 81 and 82 on the information below.

A lightbulb contains argon gas at a temperature of 295 K and at a pressure of 75 kilopascals. The lightbulb is switched on, and after 30 minutes its temperature is 418 K.

81 In the space *in your answer booklet,* show a correct numerical setup for calculating the pressure of the gas inside the lightbulb at 418 K. Assume the volume of the lightbulb remains constant. [1]

82 What Celsius temperature is equal to 418 K? [1]

83 Because tap water is slightly acidic, water pipes made of iron corrode over time, as shown by the balanced ionic equation below:

$$2Fe + 6H^+ \rightarrow 2Fe^{3+} + 3H_2$$

Explain, in terms of chemical reactivity, why copper pipes are *less* likely to corrode than iron pipes. [1]

Base your answers to questions 71 through 74 on the passage below.

Acid rain lowers the pH in ponds and lakes and over time can cause the death of some aquatic life. Acid rain is caused in large part by the burning of fossil fuels in power plants and by gasoline-powered vehicles. The acids commonly associated with acid rain are sulfurous acid, sulfuric acid, and nitric acid.

In general, fish can tolerate a pH range between 5 and 9. However, even small changes in pH can significantly affect the solubility and toxicity of common pollutants. Increased concentrations of these pollutants can adversely affect the behavior and normal life processes of fish and cause deformity, lower egg production, and less egg hatching.

71 Acid rain caused the pH of a body of water to decrease. Explain this pH decrease in terms of the change in concentration of hydronium ions. [1]

72 Write the chemical formula of a *negative* polyatomic ion present in an aqueous nitric acid solution. [1]

73 Using information in the passage, describe *one* effect of acid rain on future generations of fish species in ponds and lakes. [1]

74 Sulfur dioxide, SO_2, is one of the gases that reacts with water to produce acid rain. According to Reference Table G, describe how the solubility of sulfur dioxide in water is affected by an increase in water temperature. [1]

Base your answers to questions 75 through 77 on the information below.

A student is instructed to make 0.250 liter of a 0.200 M aqueous solution of $Ca(NO_3)_2$.

75 What is the gram-formula mass of $Ca(NO_3)_2$? [1]

76 In the space *in your answer booklet,* show a correct numerical setup for calculating the total number of moles of $Ca(NO_3)_2$ needed to make 0.250 liter of the 0.200 M calcium nitrate solution. [1]

77 In order to prepare the described solution in the laboratory, two quantities must be measured accurately. One of these quantities is the volume of the solution. What other quantity must be measured to prepare this solution? [1]