Part B–2

Answer all questions in this part.

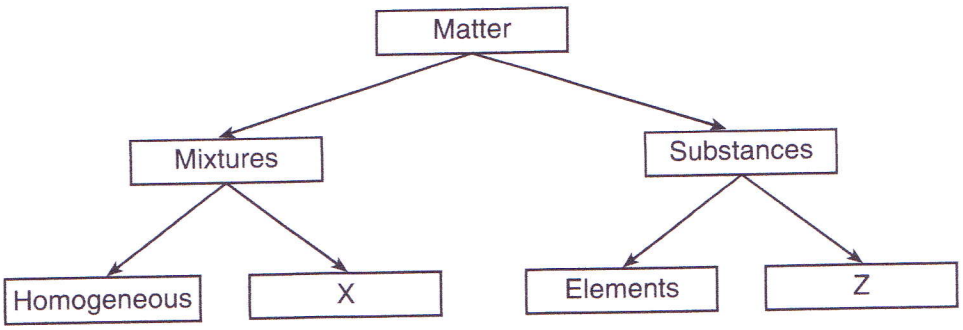
Directions (51–65): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *Reference Tables for Physical Setting/Chemistry.*

51 In the space *in your answer booklet,* draw a Lewis electron-dot diagram for a sulfur atom in the ground state. [1]

52 Explain, in terms of electron configuration, why selenium and sulfur have similar chemical properties. [1]

Base your answers to questions 53 through 56 on the diagram below concerning the classification of matter.

Classification of Matter



53 What type of mixture is represented by *X*? [1]

54 What type of substance is represented by Z? [1]

55 Explain, in terms of particle arrangement, why NaCl(aq) is a homogeneous mixture. [1]

56 Given a mixture of sand and water, state *one* process that can be used to separate water from the sand. [1]

Base your answers to questions 57 through 60 on the information below.

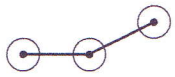
An investigation was conducted to study the effect of the concentration of a reactant on the total time needed to complete a chemical reaction. Four trials of the same reaction were performed. In each trial the initial concentration of the reactant was different. The time needed for the chemical reaction to be completed was measured. The data for each of the four trials are shown in the table below.

Reactant Concentration and Reaction Time

Trial	Initial Concentration (M)	Reaction Time (s)
1	0.020	11
2	0.015	14
3	0.010	23
4	0.005	58

57 On the grid *in your answer booklet,* mark an appropriate scale on the axis labeled "Reaction Time (s)." An appropriate scale is one that allows a trend to be seen. [1]

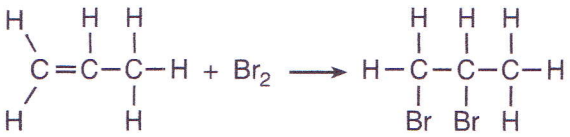
58 On the same grid, plot the data from the data table. Circle and connect the points. [1]

Example: 

59 State the effect of the concentration of the reactant on the rate of the chemical reaction. [1]

60 In a different experiment involving the same reaction, it was found that an increase in temperature increased the rate of the reaction. Explain this result in terms of collision theory. [1]

Base your answers to questions 61 through 63 on the equation below, which represents an organic compound reacting with bromine.



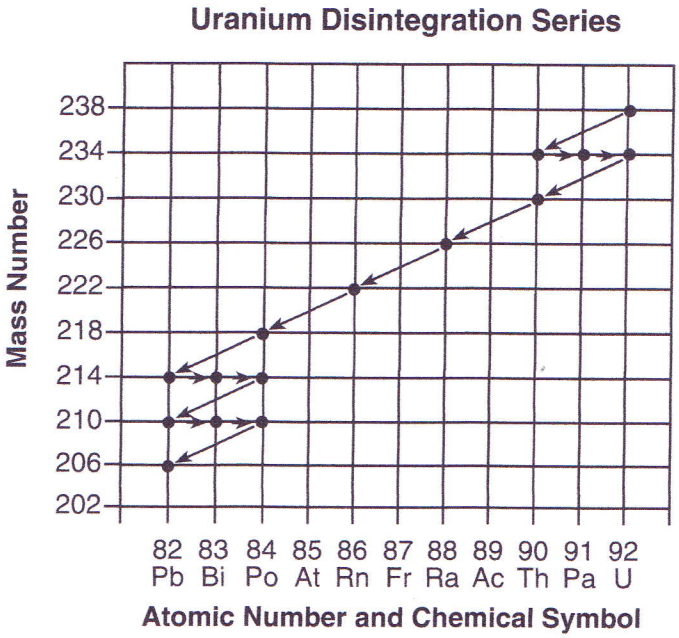
61 What is the IUPAC name for the organic compound that reacts with Br_2? [1]

62 What type of organic reaction is represented by this equation? [1]

63 What is the gram-formula mass of the product in this reaction? [1]

Base your answers to questions 64 and 65 on the information below.

A U-238 atom decays to a Pb-206 atom through a series of steps. Each point on the graph below represents a nuclide and each arrow represents a nuclear decay mode.



64 Based on this graph, what particle is emitted during the nuclear decay of a Po-218 atom? [1]

65 Explain why the U-238 disintegration series ends with the nuclide Pb-206. [1]

Part C

Answer all questions in this part.

Directions (66–85): 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 66 and 67 on the information below.

Some radioisotopes used as tracers make it possible for doctors to see the images of internal body parts and observe their functions. The table below lists information about three radioisotopes and the body part each radioisotope is used to study.

Medical Uses of Some Radioisotopes

Radioisotope	Half-life	Decay Mode	Body Part
^{24}Na	15 hours	beta	circulatory system
^{59}Fe	44.5 days	beta	red blood cells
^{131}I	8.1 days	beta	thyroid

66 Complete the equation *in your answer booklet* for the nuclear decay of the radioisotope used to study red blood cells. Include *both* the atomic number and the mass number for *each* missing particle. [1]

67 It could take up to 60. hours for a radioisotope to be delivered to the hospital from the laboratory where it is produced. What fraction of an original sample of ^{24}Na remains unchanged after 60. hours? [1]

Base your answers to questions 68 through 71 on the information below.

A metal, *M*, was obtained from a compound in a rock sample. Experiments have determined that the element is a member of Group 2 on the Periodic Table of the Elements.

68 What is the phase of element *M* at STP? [1]

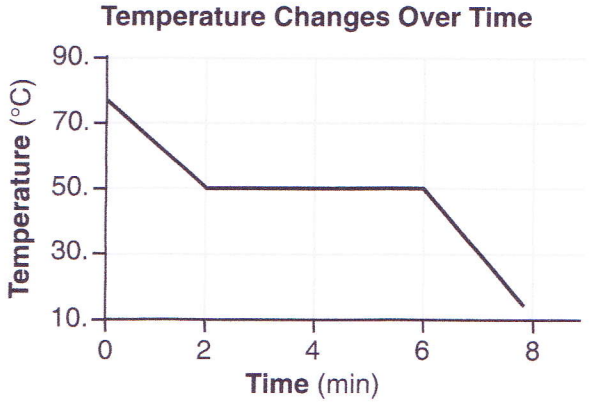
69 Explain, in terms of electrons, why element *M* is a good conductor of electricity. [1]

70 Explain why the radius of a positive ion of element *M* is *smaller* than the radius of an atom of element *M*. [1]

71 Using the symbol *M* for the element, write the chemical formula for the compound that forms when element *M* reacts with iodine. [1]

Base your answers to questions 72 through 75 on the information below.

The graph below shows a compound being cooled at a constant rate starting in the liquid phase at 75°C and ending at 15°C.



72 What is the freezing point of the compound, in degrees Celsius? [1]

73 State what is happening to the average kinetic energy of the particles of the sample between minute 2 and minute 6. [1]

74 A different experiment was conducted with another sample of the same compound starting in the solid phase. The sample was heated at a constant rate from 15°C to 75°C. On the graph *in your answer booklet,* draw the resulting heating curve. [1]

75 What kelvin temperature is equal to 15°C? [1]

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

Using burets, a student titrated a sodium hydroxide solution of unknown concentration with a standard solution of 0.10 M hydrochloric acid. The data are recorded in the table below.

Titration Data

Solution	HCl(aq)	NaOH(aq)
Initial Buret Reading (mL)	15.50	5.00
Final Buret Reading (mL)	25.00	8.80

76 Determine *both* the total volume of HCl(aq) and the total volume of NaOH(aq) used in the titration. [1]

77 In the space *in your answer booklet,* show a correct numerical setup for calculating the molarity of the sodium hydroxide solution. [1]

Base your answers to questions 78 and 79 on the information below.

Many esters have distinctive odors, which lead to their widespread use as artificial flavorings and fragrances. For example, methyl butanoate has an odor like pineapple and ethyl methanoate has an odor like raspberry.

78 In the space *in your answer booklet,* draw a structural formula for the ester that has an odor like pineapple. [1]

79 What is a chemical name for the alcohol that reacts with methanoic acid to produce the ester that has an odor like raspberry? [1]

Base your answers to questions 80 and 81 on the information below.

Three bottles of liquids labeled 1, 2, and 3 were found in a storeroom. One of the liquids is known to be drain cleaner. Drain cleaners commonly contain KOH or NaOH. The pH of each liquid at 25°C was determined with a pH meter. The table below shows the test results.

pH Test Results

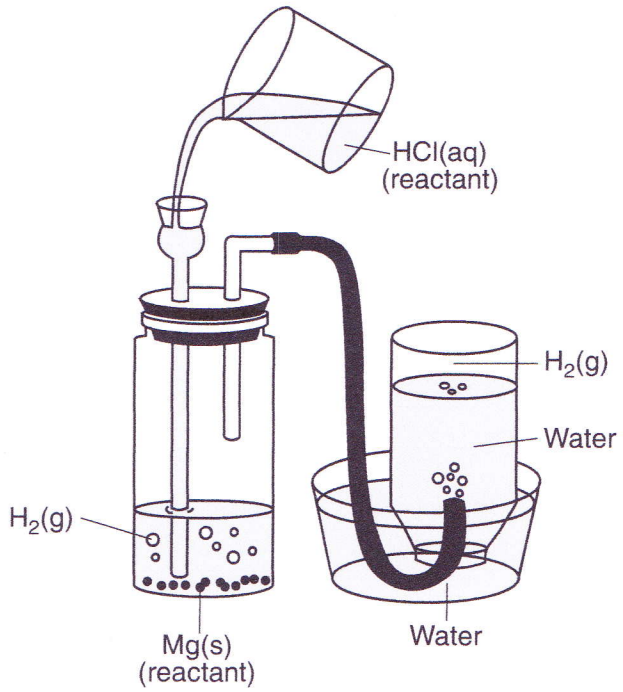
Bottle	pH of Liquid
1	3.8
2	7.0
3	12.8

80 Explain how the pH results in this table enable a student to correctly conclude that bottle 3 contains the drain cleaner. [1]

81 Explain, in terms of the pH values, why thymol blue is *not* a suitable indicator to distinguish between the contents of bottle 1 and bottle 2. [1]

Base your answers to questions 82 through 85 on the information below.

A student places a 2.50-gram sample of magnesium metal in a bottle and fits the bottle with a 2-hole stopper as shown in the diagram. Hydrochloric acid is added to the bottle, causing a reaction. As the reaction proceeds, hydrogen gas travels through the tubing to an inverted bottle filled with water, displacing some of the water in the bottle.



82 Balance the equation *in your answer booklet* for the reaction of magnesium and hydrochloric acid, using the smallest whole-number coefficients. [1]

83 Identify the type of chemical reaction that occurs when magnesium reacts with hydrochloric acid. [1]

84 In the space *in your answer booklet,* show a correct numerical setup for calculating the number of moles of magnesium used in the experiment. [1]

85 Based on Reference Table *J*, explain why Ag(s) will *not* react with HCl(aq) to generate $H_2(g)$. [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]

Base your answers to questions 73 through 75 on the information below.

A hydrate is a compound that has water molecules within its crystal structure. The formula for the hydrate $CuSO_4 \bullet 5H_2O(s)$ shows that there are five moles of water for every one mole of $CuSO_4(s)$. When $CuSO_4 \bullet 5H_2O(s)$ is heated, the water within the crystals is released, as represented by the balanced equation below.

$$CuSO_4 \bullet 5H_2O(s) \rightarrow CuSO_4(s) + 5H_2O(g)$$

A student first masses an empty crucible (a heat-resistant container). The student then masses the crucible containing a sample of $CuSO_4 \bullet 5H_2O(s)$. The student repeatedly heats and masses the crucible and its contents until the mass is constant. The student's recorded experimental data and calculations are shown below.

Data and calculation before heating:

mass of $CuSO_4 \bullet 5H_2O(s)$ and crucible	21.37 g
– mass of crucible	19.24 g
mass of $CuSO_4 \bullet 5H_2O(s)$	2.13 g

Data and calculation after heating to a constant mass:

mass of $CuSO_4(s)$ and crucible	20.61 g
– mass of crucible	19.24 g
mass of $CuSO_4(s)$	1.37 g

Calculation to determine the mass of water:

mass of $CuSO_4 \bullet 5H_2O(s)$	2.13 g
– mass of $CuSO_4(s)$	1.37 g
mass of $H_2O(g)$	0.76 g

73 Identify the total number of significant figures recorded in the calculated mass of $CuSO_4 \bullet 5H_2O(s)$. [1]

74 In the space *in your answer booklet*, use the student's data to show a correct numerical setup for calculating the percent composition by mass of water in the hydrate. [1]

75 Explain why the sample in the crucible must be heated until the constant mass is reached. [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]

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.

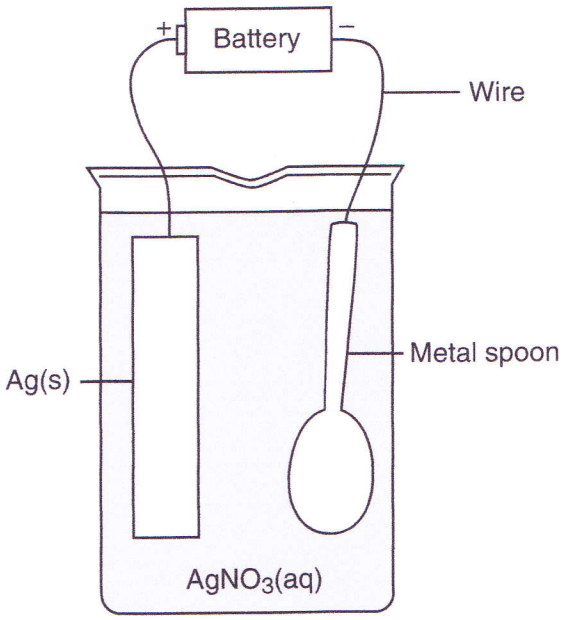
81 Determine the approximate age of these fossilized remains. [1]

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 83 and 84 on the information below.

Electroplating is an electrolytic process used to coat metal objects with a more expensive and less reactive metal. The diagram below shows an electroplating cell that includes a battery connected to a silver bar and a metal spoon. The bar and spoon are submerged in $AgNO_3(aq)$.

An Electroplating Cell



83 Explain why $AgNO_3$ is a better choice than AgCl for use in this electrolytic process. [1]

84 Explain the purpose of the battery in this cell. [1]