The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
CHEMISTRY

Tuesday, June 24, 2014 — 9:15 a.m. to 12:15 p.m., only

The possession or use of any communications device is strictly prohibited when taking this examination. If you have or use any communications device, no matter how briefly, your examination will be invalidated and no score will be calculated for you.

This is a test of your knowledge of chemistry. Use that knowledge to answer all questions in this examination. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*. You are to answer *all* questions in all parts of this examination according to the directions provided in this examination booklet.

A separate answer sheet for Part A and Part B–1 has been provided to you. Follow the instructions from the proctor for completing the student information on your answer sheet. Record your answers to the Part A and Part B–1 multiple-choice questions on this separate answer sheet. Record your answers for the questions in Part B–2 and Part C in your separate answer booklet. Be sure to fill in the heading on the front of your answer booklet.

All answers in your answer booklet should be written in pen, except for graphs and drawings, which should be done in pencil. You may use scrap paper to work out the answers to the questions, but be sure to record all your answers on your separate answer sheet or in your answer booklet as directed.

When you have completed the examination, you must sign the statement printed on your separate answer sheet, indicating that you had no unlawful knowledge of the questions or answers prior to the examination and that you have neither given nor received assistance in answering any of the questions during the examination. Your answer sheet and answer booklet cannot be accepted if you fail to sign this declaration.

Notice. . .

A four-function or scientific calculator and a copy of the *2011 Edition Reference Tables for Physical Setting/Chemistry* must be available for you to use while taking this examination.

DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL THE SIGNAL IS GIVEN.

Part A

Answer all questions in this part.

Directions (1–30): For *each* statement or question, record on your separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

1 Compared to the charge of a proton, the charge of an electron has

(1) a greater magnitude and the same sign
(2) a greater magnitude and the opposite sign
(3) the same magnitude and the same sign
(4) the same magnitude and the opposite sign

2 Which atom has the largest atomic radius?

(1) potassium
(2) rubidium
(3) francium
(4) cesium

3 In the wave-mechanical model of the atom, an orbital is defined as

(1) a region of the most probable proton location
(2) a region of the most probable electron location
(3) a circular path traveled by a proton around the nucleus
(4) a circular path traveled by an electron around the nucleus

4 When an excited electron in an atom moves to the ground state, the electron

(1) absorbs energy as it moves to a higher energy state
(2) absorbs energy as it moves to a lower energy state
(3) emits energy as it moves to a higher energy state
(4) emits energy as it moves to a lower energy state

5 Which polyatomic ion is found in the compound represented by the formula $NaHCO_3$?

(1) acetate
(2) hydrogen carbonate
(3) hydrogen sulfate
(4) oxalate

6 The atomic mass of magnesium is the weighted average of the atomic masses of

(1) all of the artificially produced isotopes of Mg
(2) all of the naturally occurring isotopes of Mg
(3) the two most abundant artificially produced isotopes of Mg
(4) the two most abundant naturally occurring isotopes of Mg

7 Which element has atoms that can form halide ions?

(1) iodine
(2) silver
(3) strontium
(4) xenon

8 Two forms of solid carbon, diamond and graphite, differ in their physical properties due to the differences in their

(1) atomic numbers
(2) crystal structures
(3) isotopic abundances
(4) percent compositions

9 Which quantity can be calculated for a solid compound, given only the formula of the compound and the Periodic Table of the Elements?

(1) the density of the compound
(2) the heat of fusion of the compound
(3) the melting point of each element in the compound
(4) the percent composition by mass of each element in the compound

10 Which terms identify types of chemical reactions?

(1) decomposition and sublimation
(2) decomposition and synthesis
(3) deposition and sublimation
(4) deposition and synthesis

11 The greatest amount of energy released per gram of reactants occurs during a

(1) redox reaction
(2) fission reaction
(3) substitution reaction
(4) neutralization reaction

12 Which element has atoms with the strongest attraction for electrons in a chemical bond?

(1) chlorine
(2) nitrogen
(3) fluorine
(4) oxygen

13 Compared to the physical and chemical properties of the compound NO_2, the compound N_2O has

(1) different physical properties and different chemical properties
(2) different physical properties and the same chemical properties
(3) the same physical properties and different chemical properties
(4) the same physical properties and the same chemical properties

14 Which phrase describes a molecule of CH_4, in terms of molecular polarity and distribution of charge?

(1) polar with an asymmetrical distribution of charge
(2) polar with a symmetrical distribution of charge
(3) nonpolar with an asymmetrical distribution of charge
(4) nonpolar with a symmetrical distribution of charge

15 Which sample of copper has atoms with the *lowest* average kinetic energy?

(1) 10. g at 45°C
(2) 20. g at 35°C
(3) 30. g at 25°C
(4) 40. g at 15°C

16 Which change results in the formation of different substances?

(1) burning of propane
(2) melting of NaCl(s)
(3) deposition of $CO_2(g)$
(4) solidification of water

17 Which substance can *not* be broken down by a chemical change?

(1) ammonia
(2) ethanol
(3) propanal
(4) zirconium

18 According to Table *I*, which equation represents a change resulting in the greatest quantity of energy released?

(1) $2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$
(2) $2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$
(3) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
(4) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

19 Which element is a liquid at STP?

(1) bromine
(2) cesium
(3) francium
(4) iodine

20 Which statement describes a reversible reaction at equilibrium?

(1) The activation energy of the forward reaction must equal the activation energy of the reverse reaction.
(2) The rate of the forward reaction must equal the rate of the reverse reaction.
(3) The concentration of the reactants must equal the concentration of the products.
(4) The potential energy of the reactants must equal the potential energy of the products.

21 Given the balanced equation representing a reaction:

$$O_2 \rightarrow O + O$$

What occurs during this reaction?

(1) Energy is absorbed as bonds are broken.
(2) Energy is absorbed as bonds are formed.
(3) Energy is released as bonds are broken.
(4) Energy is released as bonds are formed.

22 In terms of entropy and energy, systems in nature tend to undergo changes toward

(1) lower entropy and lower energy
(2) lower entropy and higher energy
(3) higher entropy and lower energy
(4) higher entropy and higher energy

23 Which term is defined as the difference between the potential energy of the products and the potential energy of the reactants in a chemical reaction?

(1) activation energy
(2) thermal energy
(3) heat of fusion
(4) heat of reaction

24 What is the atomic number of the element whose atoms bond to each other in chains, rings, and networks?

(1) 10
(2) 8
(3) 6
(4) 4

25 How many pairs of electrons are shared between two adjacent carbon atoms in a saturated hydrocarbon?

(1) 1
(2) 2
(3) 3
(4) 4

26 Given the balanced equation representing a reaction:

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

As the aluminum loses 12 moles of electrons, the oxygen

(1) gains 4 moles of electrons
(2) gains 12 moles of electrons
(3) loses 4 moles of electrons
(4) loses 12 moles of electrons

27 Which compound is an electrolyte?

(1) CH_3CHO
(2) CH_3OCH_3
(3) CH_3COOH
(4) $CH_3CH_2CH_3$

28 Which statement describes one acid-base theory?

(1) An acid is an H^+ acceptor, and a base is an H^+ donor.
(2) An acid is an H^+ donor, and a base is an H^+ acceptor.
(3) An acid is an H^- acceptor, and a base is an H^- donor.
(4) An acid is an H^- donor, and a base is an H^- acceptor.

29 Which compounds are classified as Arrhenius acids?

(1) HCl and NaOH
(2) HNO_3 and NaCl
(3) NH_3 and H_2CO_3
(4) HBr and H_2SO_4

30 Which statement describes the stability of the nuclei of potassium atoms?

(1) All potassium atoms have stable nuclei that spontaneously decay.
(2) All potassium atoms have unstable nuclei that do not spontaneously decay.
(3) Some potassium atoms have unstable nuclei that spontaneously decay.
(4) Some potassium atoms have unstable nuclei that do not spontaneously decay.

Part B–1

Answer all questions in this part.

Directions (31–50): For *each* statement or question, record on your separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

31 Which notations represent different isotopes of the element sodium?

(1) ^{32}S and ^{34}S
(2) S^{2-} and S^{6+}
(3) Na^{+} and Na^{0}
(4) ^{22}Na and ^{23}Na

32 Which electron configuration represents the electrons in an atom of Ga in an excited state?

(1) 2-8-17-3
(2) 2-8-17-4
(3) 2-8-18-3
(4) 2-8-18-4

33 Which statement describes the general trends in electronegativity and first ionization energy as the elements in Period 3 are considered in order from Na to Cl?

(1) Electronegativity increases, and first ionization energy decreases.
(2) Electronegativity decreases, and first ionization energy increases.
(3) Electronegativity and first ionization energy both increase.
(4) Electronegativity and first ionization energy both decrease.

34 What is the gram-formula mass of $Fe(NO_3)_3$?

(1) 146 g/mol
(2) 194 g/mol
(3) 214 g/mol
(4) 242 g/mol

35 Given the balanced equation representing a reaction:

$$Al_2(SO_4)_3 + 6NaOH \rightarrow 2Al(OH)_3 + 3Na_2SO_4$$

The mole ratio of NaOH to $Al(OH)_3$ is

(1) 1:1
(2) 1:3
(3) 3:1
(4) 3:7

36 Which equation represents a single replacement reaction?

(1) $2H_2O_2 \rightarrow 2H_2O + O_2$
(2) $2H_2 + O_2 \rightarrow 2H_2O$
(3) $H_2SO_4 + Mg \rightarrow H_2 + MgSO_4$
(4) $HCl + KOH \rightarrow KCl + H_2O$

37 The accepted value for the percent by mass of water in a hydrate is 36.0%. In a laboratory activity, a student determined the percent by mass of water in the hydrate to be 37.8%. What is the percent error for the student's measured value?

(1) 5.0%
(2) 4.8%
(3) 1.8%
(4) 0.05%

38 The boiling points, at standard pressure, of four compounds are given in the table below.

Boiling Points of Four Compounds

Compound	Boiling Point (°C)
H_2O	100.0
H_2S	−59.6
H_2Se	−41.3
H_2Te	−2.0

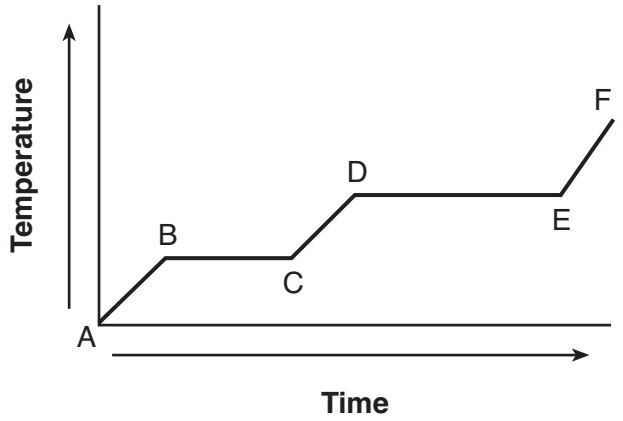
Which type of attraction can be used to explain the unusually high boiling point of H_2O?

(1) ionic bonding
(2) hydrogen bonding
(3) polar covalent bonding
(4) nonpolar covalent bonding

39 Which formula represents a molecule with the most polar bond?

(1) CO
(2) NO
(3) HI
(4) HCl

40 The graph below represents the uniform heating of a substance from the solid to the gas phase.



Which line segment of the graph represents boiling?

(1) $\overline{AB}$
(2) $\overline{BC}$
(3) $\overline{CD}$
(4) $\overline{DE}$

41 A 1-gram sample of a compound is added to 100 grams of $H_2O(\ell)$ and the resulting mixture is then thoroughly stirred. Some of the compound is then separated from the mixture by filtration. Based on Table *F*, the compound could be

(1) AgCl
(2) $CaCl_2$
(3) NaCl
(4) $NiCl_2$

42 At standard pressure, the total amount of heat required to completely vaporize a 100.-gram sample of water at its boiling point is

(1) 2.26×10 J
(2) 2.26×10^2 J
(3) 2.26×10^3 J
(4) 2.26×10^5 J

43 A sample of helium gas is in a sealed, rigid container. What occurs as the temperature of the sample is increased?

(1) The mass of the sample decreases.
(2) The number of moles of gas increases.
(3) The volume of each atom decreases.
(4) The frequency of collisions between atoms increases.

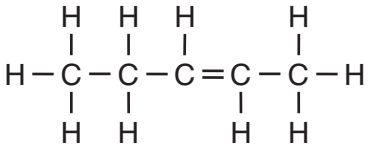
44 Given the equation representing a reaction at equilibrium:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + \text{heat}$$

Which change causes the equilibrium to shift to the right?

(1) adding a catalyst
(2) adding more $O_2(g)$
(3) decreasing the pressure
(4) increasing the temperature

45 Given the formula representing a compound:



What is a chemical name of this compound?

(1) 2-pentene
(2) 2-pentyne
(3) 3-pentene
(4) 3-pentyne

46 What is the oxidation number of manganese in $KMnO_4$?

(1) +7
(2) +2
(3) +3
(4) +4

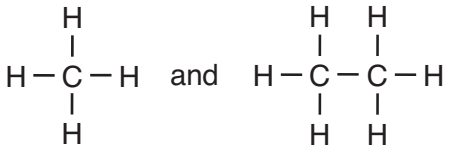
47 When the pH of an aqueous solution is changed from 1 to 2, the concentration of hydronium ions in the solution is

(1) decreased by a factor of 2
(2) decreased by a factor of 10
(3) increased by a factor of 2
(4) increased by a factor of 10

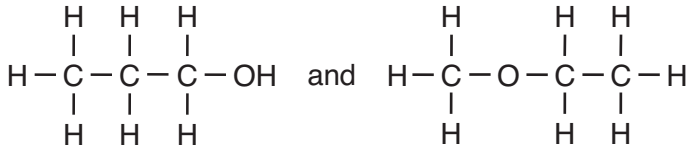
48 What is the color of the indicator thymol blue in a solution that has a pH of 11?

(1) red
(2) blue
(3) pink
(4) yellow

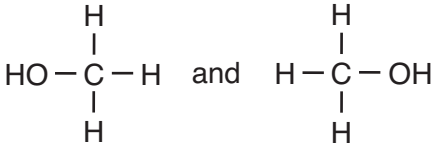
49 Which formulas represent compounds that are isomers of each other?



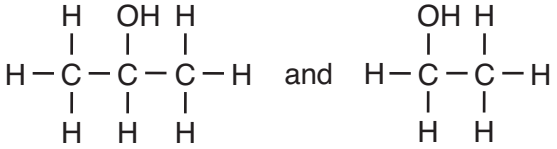
(1)



(3)



(2)



(4)

50 One beneficial use of radioisotopes is

(1) detection of disease
(2) neutralization of an acid spill
(3) decreasing the dissolved $O_2(g)$ level in seawater
(4) increasing the concentration of $CO_2(g)$ in the atmosphere

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 *2011 Edition Reference Tables for Physical Setting/Chemistry.*

51 Draw a Lewis electron-dot diagram for a molecule of bromomethane, CH_3Br. [1]

52 Explain, in terms of atomic structure, why Group 18 elements on the Periodic Table rarely form compounds. [1]

53 Explain, in terms of electrons, why the radius of a potassium atom is larger than the radius of a potassium ion in the ground state. [1]

54 Identify the type of bonding in solid potassium. [1]

Base your answers to questions 55 and 56 on the information below and on your knowledge of chemistry.

A 2.50-liter aqueous solution contains 1.25 moles of dissolved sodium chloride. The dissolving of NaCl(s) in water is represented by the equation below.

$$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$$

55 Determine the molarity of this solution. [1]

56 Compare the freezing point of this solution to the freezing point of a solution containing 0.75 mole NaCl per 2.50 liters of solution. [1]

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

A 1.00-mole sample of glucose, $C_6H_{12}O_6$, completely reacts with oxygen, as represented by the balanced equation below.

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(\ell) + \text{energy}$$

57 Write the empirical formula for glucose. [1]

58 Using the axes *in your answer booklet*, complete the potential energy curve for the reaction of glucose with oxygen. [1]

Base your answers to questions 59 through 61 on the information below and on your knowledge of chemistry.

Ethane, C_2H_6, has a boiling point of $-89°C$ at standard pressure. Ethanol, C_2H_5OH, has a much higher boiling point than ethane at standard pressure. At STP, ethane is a gas and ethanol is a liquid.

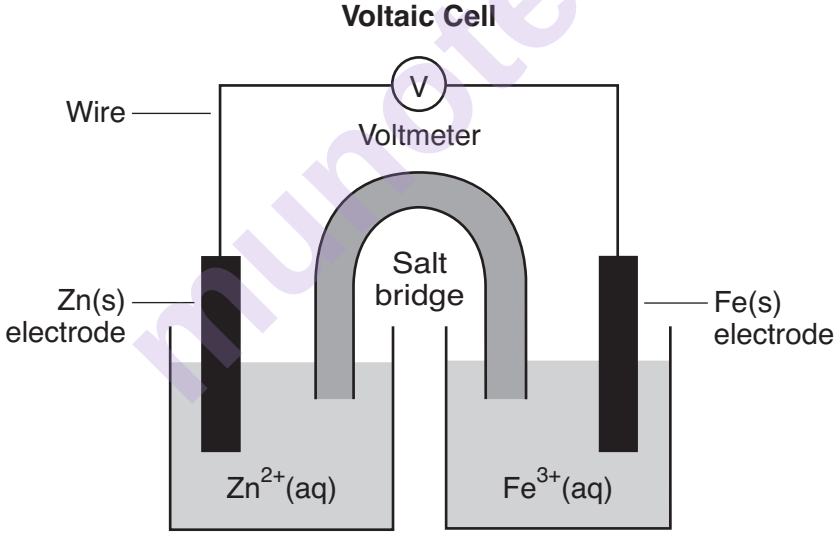
59 Identify the class of organic compounds to which ethanol belongs. [1]

60 A liquid boils when the vapor pressure of the liquid equals the atmospheric pressure on the surface of the liquid. Based on Table *H*, what is the boiling point of ethanol at standard pressure? [1]

61 Compare the intermolecular forces of the two substances at STP. [1]

Base your answers to questions 62 through 65 on the information below and on your knowledge of chemistry.

An operating voltaic cell has zinc and iron electrodes. The cell and the unbalanced ionic equation representing the reaction that occurs in the cell are shown below.



$$Zn(s) + Fe^{3+}(aq) \longrightarrow Zn^{2+}(aq) + Fe(s)$$

62 Identify the subatomic particles that flow through the wire as the cell operates. [1]

63 Balance the equation *in your answer booklet* for the redox reaction that occurs in this cell, using the smallest whole-number coefficients. [1]

64 Identify *one* metal from Table *J* that is more easily oxidized than Zn. [1]

65 Explain, in terms of Zn atoms and Zn ions, why the mass of the Zn electrode *decreases* as the cell operates. [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 *2011 Edition Reference Tables for Physical Setting/Chemistry*.

Base your answers to questions 66 through 69 on the information below and on your knowledge of chemistry.

A student compares some models of the atom. These models are listed in the table below in order of development from top to bottom.

Models of the Atom

Model	Observation	Conclusion
Dalton model	Matter is conserved during a chemical reaction.	Atoms are hard, indivisible spheres of different sizes.
Thomson model	Cathode rays are deflected by magnetic/electric fields.	Atoms have small, negatively charged particles as part of their internal structure.
Rutherford model	Most alpha particles pass straight through gold foil but a few are deflected.	An atom is mostly empty space with a small, dense, positively charged nucleus.
Bohr model	Unique spectral lines are emitted by excited gaseous elements.	Packets of energy are absorbed or emitted by atoms when an electron changes shells.

66 State the model that first included electrons as subatomic particles. [1]

67 State *one* conclusion about the internal structure of the atom that resulted from the gold foil experiment. [1]

68 Using the conclusion from the Rutherford model, identify the charged subatomic particle that is located in the nucleus. [1]

69 State *one* way in which the Bohr model agrees with the Thomson model. [1]

Base your answers to questions 70 through 72 on the information below and on your knowledge of chemistry.

Paintball is a popular recreational activity that uses a metal tank of compressed carbon dioxide or nitrogen to launch small capsules of paint. A typical tank has a volume of 508 cubic centimeters. A 340.-gram sample of carbon dioxide is added to the tank before it is used for paintball. At 20.°C, this tank contains both $CO_2(g)$ and $CO_2(\ell)$. After a paintball game, the tank contains only $CO_2(g)$.

70 Determine the total number of moles of CO_2 added to the tank before it is used for paintball. [1]

71 In the box *in your answer booklet*, use the key to draw a particle diagram to represent the two phases of CO_2 in a newly filled tank. Your response must include *at least six* molecules of CO_2 in *each* phase. [1]

72 After the paintball game, the tank has a gas pressure of 6.1 atmospheres and is at 293 K. If the tank is heated to 313 K, the pressure in the tank will change. Show a numerical setup for calculating the pressure of the gas in the tank at 313 K. [1]

Base your answers to questions 73 through 75 on the information below and on your knowledge of chemistry.

Many breads are made by adding yeast to dough, causing the dough to rise. Yeast is a type of microorganism that produces the catalyst zymase, which converts glucose, $C_6H_{12}O_6$, to ethanol and carbon dioxide gas. The balanced equation for this reaction is shown below.

$$C_6H_{12}O_6(aq) \xrightarrow{\text{zymase}} 2C_2H_5OH(aq) + 2CO_2(g)$$

73 Draw a structural formula for the ethanol formed during this reaction. [1]

74 Describe how the catalyst, zymase, speeds up this reaction. [1]

75 Determine the total mass of ethanol produced when 270. grams of glucose reacts completely to form ethanol and 132 grams of carbon dioxide. [1]

Base your answers to questions 76 through 79 on the information below and on your knowledge of chemistry.

During a laboratory activity, a student places 25.0 mL of HCl(aq) of unknown concentration into a flask. The student adds four drops of phenolphthalein to the solution in the flask. The solution is titrated with 0.150 M KOH(aq) until the solution appears faint pink. The volume of KOH(aq) added is 18.5 mL.

76 What number of significant figures is used to express the concentration of the KOH(aq)? [1]

77 Complete the equation *in your answer booklet* for the neutralization reaction that occurs during the titration. [1]

78 Determine the concentration of the HCl(aq) solution, using the titration data. [1]

79 Describe *one* laboratory safety procedure that should be used if a drop of the KOH(aq) is spilled on the arm of the student. [1]

Base your answers to questions 80 through 82 on the information below and on your knowledge of chemistry.

A few pieces of dry ice, $CO_2(s)$, at $-78°C$ are placed in a flask that contains air at 21°C. The flask is sealed by placing an uninflated balloon over the mouth of the flask. As the balloon inflates, the dry ice disappears and no liquid is observed in the flask.

80 State the direction of heat flow that occurs between the dry ice and the air in the flask. [1]

81 Write the name of the process that occurs as the dry ice undergoes a phase change in the flask. [1]

82 Compare the entropy of the CO_2 molecules in the dry ice to the entropy of the CO_2 molecules in the inflated balloon. [1]

Base your answers to questions 83 through 85 on the information below and on your knowledge of chemistry.

Illuminated EXIT signs are used in public buildings such as schools. If the word EXIT is green, the sign may contain the radioisotope tritium, hydrogen-3. The tritium is a gas sealed in glass tubes. The emissions from the decay of the tritium gas cause a coating on the inside of the tubes to glow.

83 State, in terms of neutrons, how an atom of tritium *differs* from an atom of hydrogen-1. [1]

84 Determine the fraction of an original sample of tritium that remains unchanged after 24.62 years. [1]

85 Complete the nuclear equation *in your answer booklet* for the radioactive decay of tritium, by writing a notation for the missing product. [1]

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