

The University of the State of New York
REGENTS HIGH SCHOOL EXAMINATION

**PHYSICAL SETTING
CHEMISTRY**

Friday, January 25, 2019 — 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*.

- The results of the gold foil experiment led to the conclusion that an atom is
 - mostly empty space and has a small, negatively charged nucleus
 - mostly empty space and has a small, positively charged nucleus
 - a hard sphere and has a large, negatively charged nucleus
 - a hard sphere and has a large, positively charged nucleus
- Atoms are neutral because the number of
 - protons equals the number of neutrons
 - protons equals the number of electrons
 - neutrons is greater than the number of protons
 - neutrons is greater than the number of electrons
- In the ground state, valence electrons of a krypton atom are found in
 - the first shell
 - the outermost shell
 - both the nucleus and the first shell
 - both the first shell and the outermost shell
- According to the wave-mechanical model of the atom, electrons are located in
 - orbitals
 - circular paths
 - a small, dense nucleus
 - a hard, indivisible sphere
- Which electron configuration represents the electrons in an atom of sodium in the ground state at STP?
 - 2-8-1
 - 2-7-2
 - 2-8-6
 - 2-7-7
- The elements on the Periodic Table of the Elements are arranged in order of increasing
 - atomic number
 - mass number
 - number of neutrons
 - number of valence electrons
- Which element is malleable at STP?
 - chlorine
 - copper
 - helium
 - sulfur
- At 298 K and 1 atm, which noble gas has the lowest density?
 - Ne
 - Kr
 - Xe
 - Rn
- Which two terms represent types of chemical formulas?
 - empirical and molecular
 - polar and nonpolar
 - synthesis and decomposition
 - saturated and concentrated
- Which quantities are conserved in all chemical reactions?
 - charge, pressure, and energy
 - charge, mass, and energy
 - volume, pressure, and energy
 - volume, mass, and pressure
- Which term represents the sum of the atomic masses of the atoms in a molecule?
 - atomic number
 - mass number
 - formula mass
 - percent composition by mass

- 12 Which equation represents energy being absorbed as a bond is broken?
- (1) $\text{H} + \text{H} \rightarrow \text{H}_2 + \text{energy}$
 - (2) $\text{H} + \text{H} + \text{energy} \rightarrow \text{H}_2$
 - (3) $\text{H}_2 \rightarrow \text{H} + \text{H} + \text{energy}$
 - (4) $\text{H}_2 + \text{energy} \rightarrow \text{H} + \text{H}$
- 13 Which term is used to describe the attraction that an oxygen atom has for the electrons in a chemical bond?
- (1) alkalinity
 - (2) electronegativity
 - (3) electron configuration
 - (4) first ionization energy
- 14 Which substance can *not* be decomposed by chemical means?
- (1) C
 - (2) CO
 - (3) CO_2
 - (4) C_3O_2
- 15 A beaker contains a dilute sodium chloride solution at 1 atmosphere. What happens to the number of solute particles in the solution and the boiling point of the solution, as more sodium chloride is dissolved?
- (1) The number of solute particles increases, and the boiling point increases.
 - (2) The number of solute particles increases, and the boiling point decreases.
 - (3) The number of solute particles decreases, and the boiling point increases.
 - (4) The number of solute particles decreases, and the boiling point decreases.
- 16 Which form of energy is transferred when an ice cube at 0°C is placed in a beaker of water at 50°C ?
- (1) chemical
 - (2) electrical
 - (3) nuclear
 - (4) thermal
- 17 The average kinetic energy of the particles in a sample of matter is expressed as
- (1) density
 - (2) volume
 - (3) pressure
 - (4) temperature
- 18 At STP, which gas sample has the same number of molecules as 2.0 liters of $\text{CH}_4(\text{g})$ at STP?
- (1) 1.0 liter of $\text{C}_2\text{H}_6(\text{g})$
 - (2) 2.0 liters of $\text{O}_2(\text{g})$
 - (3) 5.0 liters of $\text{N}_2(\text{g})$
 - (4) 6.0 liters of $\text{CO}_2(\text{g})$
- 19 Given the equation:
- $$\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g})$$
- Which phrase describes this change?
- (1) endothermic chemical change
 - (2) endothermic physical change
 - (3) exothermic chemical change
 - (4) exothermic physical change
- 20 Which term identifies a factor that will shift a chemical equilibrium?
- (1) atomic radius
 - (2) catalyst
 - (3) decay mode
 - (4) temperature
- 21 According to which theory or law is a chemical reaction most likely to occur when two particles with the proper energy and orientation interact with each other?
- (1) atomic theory
 - (2) collision theory
 - (3) combined gas law
 - (4) law of conservation of matter
- 22 Addition of a catalyst can speed up a reaction by providing an alternate reaction pathway that has a
- (1) lower activation energy
 - (2) higher activation energy
 - (3) lower heat of reaction
 - (4) higher heat of reaction
- 23 Which compound is saturated?
- (1) butane
 - (2) ethene
 - (3) heptene
 - (4) pentyne

- 24 An alcohol and an ether have the same molecular formula, C_2H_6O . These two compounds have
- (1) the same functional group and the same physical and chemical properties
 - (2) the same functional group and different physical and chemical properties
 - (3) different functional groups and the same physical and chemical properties
 - (4) different functional groups and different physical and chemical properties
- 25 Which metal is most easily oxidized?
- (1) Ag
 - (2) Co
 - (3) Cu
 - (4) Mg
- 26 Which substance is an Arrhenius acid?
- (1) H_2
 - (2) HCl
 - (3) KCl
 - (4) NH_3
- 27 Which statement describes an electrolyte?
- (1) An electrolyte conducts an electric current as a solid and dissolves in water.
 - (2) An electrolyte conducts an electric current as a solid and does not dissolve in water.
 - (3) When an electrolyte dissolves in water, the resulting solution conducts an electric current.
 - (4) When an electrolyte dissolves in water, the resulting solution does not conduct an electric current.
- 28 Which type of reaction occurs when an Arrhenius acid reacts with an Arrhenius base to form a salt and water?
- (1) combustion
 - (2) decomposition
 - (3) neutralization
 - (4) saponification
- 29 Compared to the energy released per mole of reactant during chemical reactions, the energy released per mole of reactant during nuclear reactions is
- (1) much less
 - (2) much greater
 - (3) slightly less
 - (4) slightly greater
- 30 Which phrase describes a risk of using the radioisotope Co-60 in treating cancer?
- (1) production of acid rain
 - (2) production of greenhouse gases
 - (3) increased biological exposure
 - (4) increased ozone depletion
-

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*.

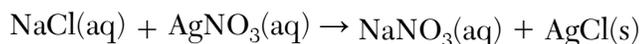
- 31 The three nuclides, U-233, U-235, and U-238, are isotopes of uranium because they have the same number of protons per atom and
- (1) the same number of electrons per atom
 - (2) the same number of neutrons per atom
 - (3) a different number of electrons per atom
 - (4) a different number of neutrons per atom
- 32 Given the information in the table below:

Two Forms of Carbon

Form	Bonding	Hardness	Electrical Conductivity
diamond	Each carbon atom bonds to four other carbon atoms in a three-dimensional network.	very hard	no
graphite	Each carbon atom bonds to three other carbon atoms in two-dimensional sheets.	soft	yes

Diamond and graphite have different properties because they have different

- (1) crystal structures
 - (2) electronegativities
 - (3) numbers of protons per atom
 - (4) numbers of valence electrons per atom
- 33 Given the equation representing a chemical reaction:



This reaction is classified as a

- (1) synthesis reaction
- (2) decomposition reaction
- (3) single replacement reaction
- (4) double replacement reaction

34 What is the formula for iron(II) oxide?

- (1) FeO (3) Fe₂O
(2) FeO₂ (4) Fe₂O₃

35 Given the reaction:



How many moles of KClO₃ must completely react to produce 6 moles of O₂?

- (1) 1 mole (3) 6 moles
(2) 2 moles (4) 4 moles

36 What is the number of moles of CO₂ in a 220.-gram sample of CO₂ (gram-formula mass = 44 g/mol)?

- (1) 0.20 mol (3) 15 mol
(2) 5.0 mol (4) 44 mol

37 A solution contains 25 grams of KNO₃ dissolved in 200. grams of H₂O. Which numerical setup can be used to calculate the percent by mass of KNO₃ in this solution?

- (1) $\frac{25 \text{ g}}{175 \text{ g}} \times 100$ (3) $\frac{25 \text{ g}}{225 \text{ g}} \times 100$
(2) $\frac{25 \text{ g}}{200. \text{ g}} \times 100$ (4) $\frac{200. \text{ g}}{225 \text{ g}} \times 100$

38 What is the molarity of 0.50 liter of an aqueous solution that contains 0.20 mole of NaOH (gram-formula mass = 40. g/mol)?

- (1) 0.10 M (3) 2.5 M
(2) 0.20 M (4) 0.40 M

39 A mixture consists of ethanol and water. Some properties of ethanol and water are given in the table below.

Some Properties of Ethanol and Water

Property	Ethanol	Water
boiling point at standard pressure	78°C	100.°C
density at STP	0.80 g/cm ³	1.00 g/cm ³
flammability	flammable	nonflammable
melting point	-114°C	0.°C

Which statement describes a property of ethanol after being separated from the mixture?

- (1) Ethanol is nonflammable.
(2) Ethanol has a melting point of 0.°C.
(3) Ethanol has a density of 0.80 g/cm³ at STP.
(4) Ethanol has a boiling point of 89°C at standard pressure.

40 A rigid cylinder with a movable piston contains a sample of hydrogen gas. At 330. K, this sample has a pressure of 150. kPa and a volume of 3.50 L. What is the volume of this sample at STP?

- (1) 0.233 L (3) 4.29 L
(2) 1.96 L (4) 6.26 L

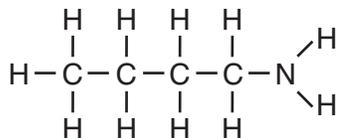
41 Which numerical setup can be used to calculate the heat energy required to completely melt 100. grams of H₂O(s) at 0°C?

- (1) (100. g)(334 J/g)
(2) (100. g)(2260 J/g)
(3) (100. g)(4.18 J/g•K)(0°C)
(4) (100. g)(4.18 J/g•K)(273 K)

42 During which phase change does the entropy of a sample of H₂O increase?

- (1) H₂O(g) → H₂O(l)
(2) H₂O(g) → H₂O(s)
(3) H₂O(l) → H₂O(g)
(4) H₂O(l) → H₂O(s)

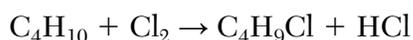
43 Given the formula for a compound:



What is a chemical name for this compound?

- (1) 1-butanamide (3) 1-butanamine
(2) 4-butanamide (4) 4-butanamine

44 Given the equation for a reaction:



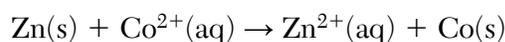
Which type of reaction is represented by the equation?

- (1) addition (3) fermentation
(2) substitution (4) polymerization

45 Which half-reaction equation represents reduction?

- (1) $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$
(2) $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
(3) $\text{Ag} + \text{e}^- \rightarrow \text{Ag}^+$
(4) $\text{Ag}^+ \rightarrow \text{Ag} + \text{e}^-$

46 Given the balanced ionic equation representing a reaction:



Which statement describes the electrons involved in this reaction?

- (1) Each Zn atom loses 2 electrons, and each Co^{2+} ion gains 2 electrons.
(2) Each Zn atom loses 2 electrons, and each Co^{2+} ion loses 2 electrons.
(3) Each Zn atom gains 2 electrons, and each Co^{2+} ion loses 2 electrons.
(4) Each Zn atom gains 2 electrons, and each Co^{2+} ion gains 2 electrons.

47 What are the two oxidation states of nitrogen in NH_4NO_2 ?

- (1) +3 and +5 (3) -3 and +3
(2) +3 and -5 (4) -3 and -3

48 The table below shows the molar concentrations of hydronium ion, H_3O^+ , in four different solutions.

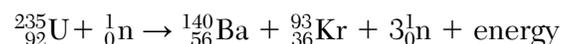
**Molar Concentration of H_3O^+ Ions
in Four Solutions**

Solution	Molar Concentration of H_3O^+ Ion (M)
A	0.1
B	0.01
C	0.001
D	0.0001

Which solution has the highest pH?

- (1) A (3) C
(2) B (4) D

49 Given the equation:



Which type of nuclear reaction is represented by the equation?

- (1) fission (3) beta decay
(2) fusion (4) alpha decay

50 Which nuclear emission has the *least* penetrating power and the greatest ionizing ability?

- (1) alpha particle (3) gamma ray
(2) beta particle (4) positron

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*.

Base your answers to questions 51 through 54 on the information below and on your knowledge of chemistry.

The formulas and names of four chloride compounds are shown in the table below.

Formula	Name
CCl_4	carbon tetrachloride
RbCl	rubidium chloride
CsCl	cesium chloride
HCl	hydrogen chloride

- 51 Identify the noble gas that has atoms with the same electron configuration as the metal ions in rubidium chloride, when both the atoms and the ions are in the ground state. [1]
- 52 Explain, in terms of atomic structure, why the radius of a cesium ion in cesium chloride is smaller than the radius of a cesium atom when both are in the ground state. [1]
- 53 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for a molecule of HCl. [1]
- 54 Explain, in terms of charge distribution, why a molecule of carbon tetrachloride is a nonpolar molecule. [1]
-

Base your answers to questions 55 through 57 on the information below and on your knowledge of chemistry.

Some isotopes of neon are Ne-19, Ne-20, Ne-21, Ne-22, and Ne-24. The neon-24 decays by beta emission. The atomic mass and natural abundance for the naturally occurring isotopes of neon are shown in the table below.

Naturally Occurring Isotopes of Neon

Isotope Notation	Atomic Mass (u)	Natural Abundance (%)
Ne-20	19.99	90.48
Ne-21	20.99	0.27
Ne-22	21.99	9.25

- 55 Identify the decay mode of Ne-19. [1]
- 56 State the number of neutrons in an atom of Ne-20 and the number of neutrons in an atom of Ne-22. [1]
- 57 Show a numerical setup for calculating the atomic mass of neon. [1]
-

Base your answers to questions 58 through 60 on the information below and on your knowledge of chemistry.

Periodic trends are observed in the properties of the elements in Period 3 on the Periodic Table. These elements vary in physical properties, such as phase, and in chemical properties, such as their ability to lose or gain electrons during a chemical reaction.

- 58 Identify the metals in Period 3 on the Periodic Table. [1]
- 59 Identify the element in Period 3 that requires the *least* amount of energy to remove the most loosely held electrons from a mole of gaseous atoms of the element in the ground state. [1]
- 60 State the general trend in atomic radius as the elements in Period 3 are considered in order of increasing atomic number. [1]
-

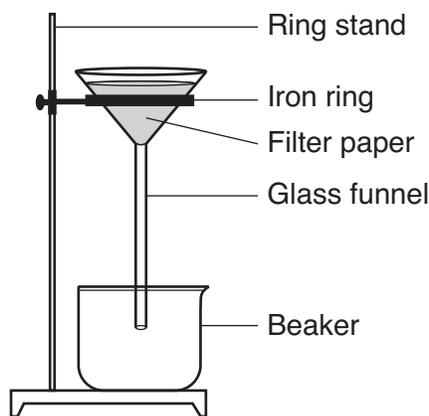
Part C

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.

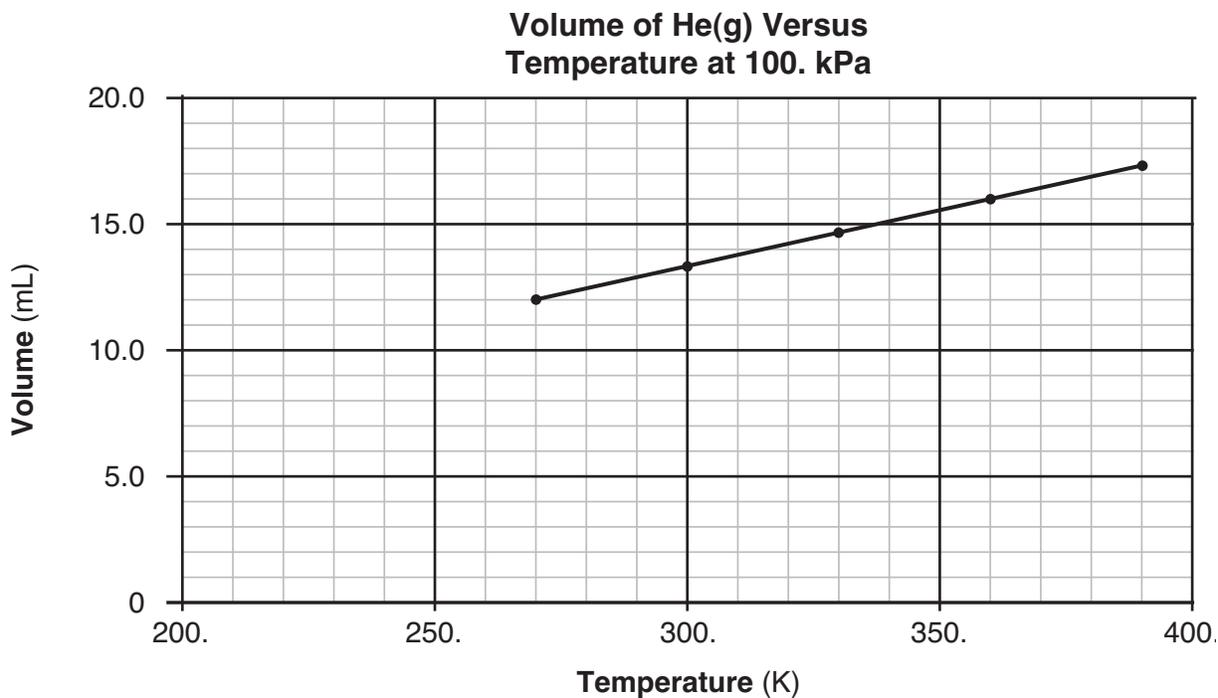
In a laboratory investigation, a student is given a sample that is a mixture of 3.0 grams of $\text{NaCl}(s)$ and 4.0 grams of sand, which is mostly $\text{SiO}_2(s)$. The purpose of the investigation is to separate and recover the compounds in the sample. In the first step, the student places the sample in a 250-mL flask. Then, 50. grams of distilled water are added to the flask, and the contents are thoroughly stirred. The mixture in the flask is then filtered, using the equipment represented by the diagram below.



- 66 Explain, in terms of solubility, why the mixture in the flask remains heterogeneous even after thorough stirring. [1]
- 67 Based on Table G, state evidence that all of the $\text{NaCl}(s)$ in the flask would dissolve in the distilled water at $20.^{\circ}\text{C}$. [1]
- 68 Describe a procedure to remove the water from the mixture that passes through the filter and collects in the beaker. [1]
- 69 The student reports that 3.4 grams of $\text{NaCl}(s)$ were recovered from the mixture. Show a numerical setup for calculating the student's percent error. [1]
-

Base your answers to questions 70 through 73 on the information below and on your knowledge of chemistry.

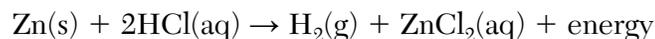
In a laboratory activity, the volume of helium gas in a rigid cylinder with a movable piston is varied by changing the temperature of the gas. The activity is done at a constant pressure of 100. kPa. Data from the activity are plotted on the graph below.



- 70 Determine the temperature of the He(g) at a volume of 15.0 mL. [1]
- 71 Explain, in terms of particle volume, why the sample of helium can *not* be compressed by the piston to zero volume. [1]
- 72 State what happens to the average distance between the He atoms as the gas is heated. [1]
- 73 State a change in pressure that will cause the helium in the cylinder to behave more like an ideal gas. [1]
-

Base your answers to questions 74 through 76 on the information below and on your knowledge of chemistry.

The balanced equation below represents the reaction between a 5.0-gram sample of zinc metal and a 0.5 M solution of hydrochloric acid. The reaction takes place in an open test tube at 298 K and 1 atm in a laboratory activity.



- 74 State *one* change in reaction conditions, other than adding a catalyst, that will increase the rate of the reaction. [1]
- 75 On the labeled axes *in your answer booklet*, draw a potential energy diagram for this reaction. [1]
- 76 Explain why this reaction will *not* reach equilibrium. [1]
-

Base your answers to questions 77 through 79 on the information below and on your knowledge of chemistry.

Crude oil, primarily a mixture of hydrocarbons, is separated into useful components in a fractionating tower. At the bottom of the tower, the crude oil is heated to about 400°C. The gases formed rise and cool. Most of the gases condense and are collected as liquid fractions. The table below shows the temperature ranges for collecting various hydrocarbon fractions.

Hydrocarbon Fractions Collected

Number of Carbon Atoms per Molecule	Temperature Range (°C)
1-4	below 40
5-12	40-200
12-16	200-300
16-20	300-370
>20	above 370

- 77 Determine the number of carbon atoms in one molecule of an alkane that has 22 hydrogen atoms in the molecule. [1]
- 78 State the temperature range for the fraction collected that contains octane molecules. [1]
- 79 Draw a structural formula for 3-ethylhexane. [1]
-

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

In a laboratory activity, a student titrates a 20.0-milliliter sample of HCl(aq) using 0.025 M NaOH(aq). In one of the titration trials, 17.6 milliliters of the base solution exactly neutralizes the acid sample.

- 80 Identify the positive ion in the sample of HCl(aq). [1]
- 81 Show a numerical setup for calculating the concentration of the hydrochloric acid using the titration data. [1]
- 82 The concentration of the base is expressed to what number of significant figures? [1]
-

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

In the past, some paints that glowed in the dark contained zinc sulfide and salts of Ra-226. As the radioisotope Ra-226 decayed, the energy released caused the zinc sulfide in these paints to emit light. The half-lives for Ra-226 and two other radioisotopes used in these paints are listed on the table below.

Radioisotopes in the Paints

Radioisotope	Half-Life (y)
Pm-147	2.6
Ra-226	1599
Ra-228	5.8

- 83 Explain, in terms of half-lives, why Ra-226 may have been used more often than the other isotopes in these paints. [1]
- 84 Complete the nuclear equation *in your answer booklet* for the beta decay of Pm-147 by writing an isotopic notation for the missing product. [1]
- 85 What fraction of an original Ra-228 sample remains unchanged after 17.4 years? [1]
-

