

1 Which statement describes the location of protons and neutrons in an atom of helium?

1. Protons and neutrons are in the nucleus.
2. Protons and neutrons are outside the nucleus.
3. Protons are outside the nucleus, and neutrons are in the nucleus.
4. Protons are in the nucleus, and neutrons are outside the nucleus.

2 Given a list of atomic model descriptions:

A: electron shells outside a central nucleus

B: hard, indivisible sphere

C: mostly empty space

Which list of atomic model descriptions represents the order of historical development from the earliest to most recent?

1. A, B, C
2. A, C, B
3. B, C, A
4. B, A, C

3 Which list represents the classification of the elements nitrogen, neon, magnesium, and silicon, respectively?

1. metal, metalloid, nonmetal, noble gas
2. nonmetal, noble gas, metal, metalloid
3. nonmetal, metalloid, noble gas, metal
4. noble gas, metal, metalloid, nonmetal

4 In the ground state, all atoms of Group 15 elements have the same number of

1. valence electrons
2. electron shells
3. neutrons
4. protons

5 What is the chemical formula for ammonium sulfide?

1.  $(\text{NH}_4)_2\text{S}$
2.  $(\text{NH}_4)_2\text{SO}_3$
3.  $(\text{NH}_4)_2\text{SO}_4$
4.  $(\text{NH}_4)_2\text{S}_2\text{O}_3$

6 Which formula is an empirical formula?

1.  $\text{N}_2\text{O}_4$
2.  $\text{NH}_3$
3.  $\text{C}_3\text{H}_6$
4.  $\text{P}_4\text{O}_{10}$

7 Chemical properties can be used to

1. determine the temperature of a substance
2. determine the density of a substance
3. differentiate between two compounds
4. differentiate between two neutrons

8 Ice,  $\text{H}_2\text{O}_{(s)}$ , is classified as

1. an ionic compound
2. a molecular compound
3. a homogeneous mixture
4. a heterogeneous mixture

9 Which phrase describes the molecular polarity and distribution of charge in a molecule of carbon dioxide,  $\text{CO}_2$ ?

1. polar and symmetrical
2. polar and asymmetrical
3. nonpolar and symmetrical
4. nonpolar and asymmetrical

10 Which element tends not to react with other elements?

1. helium
2. hydrogen
3. phosphorus
4. potassium

11 Given the equation representing a reaction:  $\text{O} + \text{O} \rightarrow \text{O}_2$

Which statement describes the changes that occur as the oxygen molecule is produced?

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.

12 Which term represents the strength of the attraction an atom has for the electrons in a chemical bond?

1. electrical conductivity
2. electronegativity
3. first ionization energy
4. specific heat capacity

13 Compared to a 15-gram sample of  $\text{Cu}_{(s)}$  at  $25^\circ\text{C}$ , a 25-gram sample of  $\text{Cu}_{(s)}$  at  $25^\circ\text{C}$  has

1. the same density and the same chemical properties
2. the same density and different chemical properties
3. a different density and the same chemical properties
4. a different density and different chemical properties

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

1. ammonia
2. ethanol
3. tungsten
4. water

15 The kinetic molecular theory states that all particles of an ideal gas are

1. colliding without transferring energy
2. in random, constant, straight-line motion
3. arranged in a regular geometric pattern
4. separated by small distances relative to their size

16 Which sample of gas at STP has the same number of molecules as 6 liters of  $\text{Cl}_2(\text{G})$  at STP?

1. 3 liters of  $\text{O}_2(\text{G})$
2. 6 liters of  $\text{N}_2(\text{G})$
3. 3 moles of  $\text{O}_2(\text{G})$
4. 6 moles of  $\text{N}_2(\text{G})$

17 A chemical reaction is most likely to occur when the colliding particles have the proper

1. energy and orientation
2. solubility and density
3. ionic radii and mass
4. atomic radii and volume

18 The energy absorbed and the energy released during a chemical reaction are best represented by a

1. cooling curve
2. heating curve
3. kinetic energy diagram
4. potential energy diagram

19 A catalyst increases the rate of a chemical reaction by

1. providing an alternate reaction pathway
2. providing the required heat of reaction
3. increasing the potential energy of the products
4. increasing the activation energy of the reaction

20 Which formula represents an alkyne?

1.  $C_nH_n$
2.  $C_{2n}H_n$
3.  $C_nH_{2n+2}$
4.  $C_nH_{2n-2}$

21 Which process involves the transfer of electrons?

1. double replacement
2. neutralization
3. oxidation-reduction
4. sublimation

22 Which change occurs at the anode in an operating electrochemical cell?

1. gain of protons
2. gain of electrons
3. loss of protons
4. loss of electrons

23 Which device requires electrical energy to produce a chemical change?

1. electrolytic cell
2. salt bridge
3. voltaic cell
4. voltmeter

24 Which substance is an Arrhenius acid? 1. HBr 2. NaBr 3. NaOH 4.  $NH_3$

25 Which laboratory process is used to determine the concentration of one solution by using a volume of another solution of known concentration?

1. crystallization
2. distillation
3. filtration
4. titration

26 Which type of reaction occurs when  $H^+_{(AQ)}$  reacts with  $OH^-_{(AQ)}$ ?

1. combustion
2. decomposition
3. fermentation
4. neutralization

27 According to one acid-base theory, a molecule acts as an acid when the molecule

1. accepts an  $H^{+1}$
2. accepts an  $OH^{-1}$
3. donates an  $H^{+1}$
4. donates an  $OH^{-1}$

28 In which type of reaction can an atom of one element be converted to an atom of another element?

1. addition
2. reduction
3. substitution
4. transmutation

29 An unstable nucleus spontaneously releases a positron. This is an example of

1. radioactive decay
2. nuclear fusion
3. chemical decomposition
4. thermal conductivity

30 Which phrase describes a risk associated with producing energy in a nuclear power plant?

1. depletion of atmospheric hydrogen ( $H_2$ )
2. depletion of atmospheric carbon dioxide ( $CO_2$ )
3. production of wastes needing long-term storage
4. production of wastes that cool surrounding water supplies

31 An ion that consists of 7 protons, 9 neutrons, and 10 electrons has a net charge of

1.  $2^{-}$
2.  $2^{+}$
3.  $3^{+}$
4.  $3^{-}$

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

1.  $2-2$
2.  $2-2-1$
3.  $2-8$
4.  $2-8-1$

33 The table below gives the atomic mass and the abundance of the two naturally occurring isotopes of boron.

Naturally Occurring Isotopes of Boron		
Isotope	Atomic Mass (u)	Natural Abundance (%)
B-10	10.01	19.9
B-11	11.01	80.1

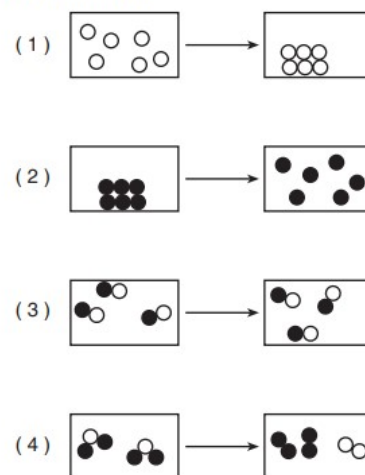
Which numerical setup can be used to determine the atomic mass of the element boron?

1.	$\frac{(10.01 \text{ u})(19.9) + (11.01 \text{ u})(80.1)}{100}$
2.	$\frac{(10.01 \text{ u})(0.199) + (11.01 \text{ u})(.801)}{100}$
3.	$\frac{(10.01 \text{ u}) + (11.01 \text{ u})}{2}$
4.	$\frac{19.9\% + 80.1\%}{2}$



41. Given the key (below), which particle diagram represents a chemical change?

Key	
○	= an atom of element A
●	= an atom of element Z



42 Based on Table H, what is the vapor pressure of  $\text{CH}_3\text{COOH}$  at  $90.^\circ\text{C}$ ?

1. 40. kPa                      2. 48 kPa                      3. 114 kPa                      4. 150. kPa

43 The arrangement of particles is most ordered in a sample of

1.  $\text{NaCl}_{(\text{Aq})}$       2.  $\text{NaCl}_{(\text{L})}$       3.  $\text{NaCl}_{(\text{G})}$       4.  $\text{NaCl}_{(\text{S})}$

44 What is the net amount of heat released when two moles of  $\text{C}_2\text{H}_6(\text{G})$  are formed from its elements at  $101.3 \text{ kPa}$  and  $298 \text{ K}$ ?

1. 42.0 kJ                      2. 84.0 kJ                      3. 126.0 kJ                      4. 168.0 kJ

45 Which compounds are isomers of each other?

1. methanol and methanal                      3. 1-propanol and 2-propanol  
2. propanoic acid and pentanoic acid                      4. 1-chloropropane and 2-bromopropane

46 A reaction between an alcohol and an organic acid is classified as

1. esterification                      3. saponification  
2. fermentation                      4. substitution

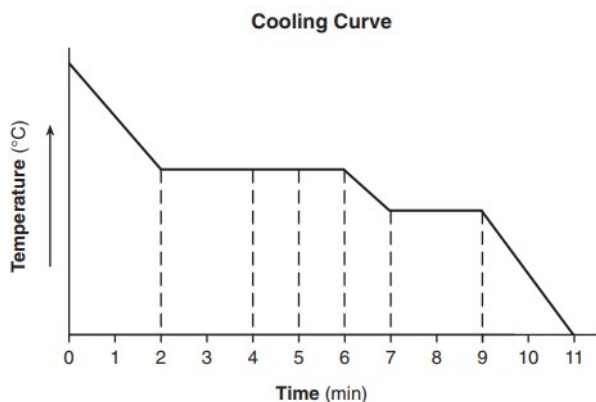
47 Why is potassium nitrate classified as an electrolyte?

1. It is a molecular compound.                      3. It can conduct electricity as a solid.  
2. It contains a metal.                      4. It releases ions in an aqueous solution.

48 When the concentration of hydrogen ions in a solution is decreased by a factor of ten, the pH of the solution

1. increases by 1                      3. decreases by 1  
2. increases by 10                      4. decreases by 10

49 The cooling curve below represents the uniform cooling of a substance, starting at a temperature above its boiling point.



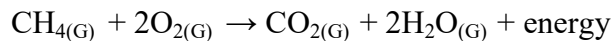
During which time interval does the substance exist as both a liquid and a solid?

- (1) min 2 to min 4
- (2) min 4 to min 5
- (3) min 5 to min 7
- (4) min 7 to min 9

During which time interval does the substance exist as both a liquid and a solid?

- 1. min 2 to min 4
- 2. min 4 to min 5
- 3. min 5 to min 7
- 4. min 7 to min 9

50 Given the balanced equation representing a reaction:



Which change in reaction conditions will increase the frequency of effective collisions between reactant molecules?

- 1. decreasing the pressure of the reactants
- 2. decreasing the temperature of the reactants
- 3. increasing the concentration of the reactants
- 4. increasing the volume of the reactants

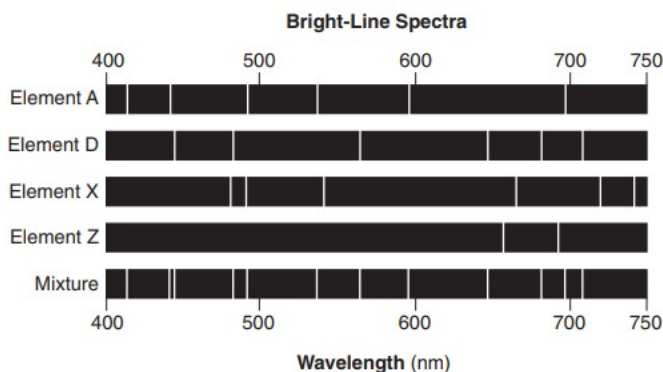
51 Convert the melting point of mercury to degrees Celsius.

52 Draw a Lewis electron-dot diagram for a molecule of hydrogen fluoride, HF.

53 Show a numerical setup for calculating the quantity of heat in joules required to completely vaporize 102.3 grams of  $\text{H}_2\text{O}_{(L)}$  at  $100.^\circ\text{C}$  and 1.0 atm.

54 State the color of methyl orange indicator after the indicator is placed in a solution of 0.10 M  $\text{NH}_3(\text{AQ})$ .

Base your answers to questions 55 and 56 on the information below and on your knowledge of chemistry. The bright-line spectra for four elements and a mixture of elements are shown in the diagram below



55 Write the letter of each element present in the mixture.

56 Explain, in terms of electrons and energy states, how the light emitted by excited atoms is produced.

Rubidium and iodine have different chemical and physical properties. Some of these properties are shown in the table below

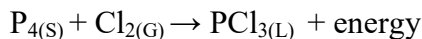
Some Physical and Chemical Properties of Rubidium and Iodine	
Rubidium	iodine
silvery-white solid	bluish-black lustrous solid
forms ionic compounds with nonmetals	forms ionic bonds with active metals
reacts with oxygen in the air	sublimes at room temperature
specific heat = $0.363 \text{ J/g}\cdot\text{K}$	specific heat = $0.363 \text{ J/g}\cdot\text{K}$

57 State the chemical property of iodine listed in this table.

58 Compare the atomic radius of an atom of iodine to the atomic radius of an atom of rubidium when both atoms are in the ground state.

59 Compare the electrical conductivity of these two elements at STP.

Given the unbalanced equation showing the reactants and product of a reaction occurring at 298 K and 100. kPa:

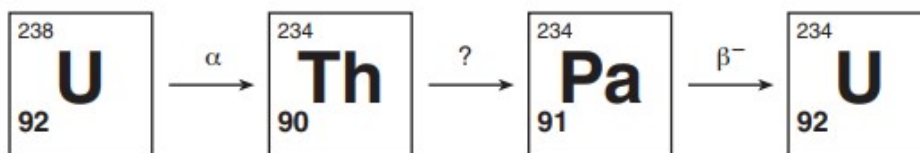


60 Balance the equation in your answer booklet for the reaction, using the smallest whole number coefficients.

61 State why this reaction is a synthesis reaction.

62 Show a numerical setup for calculating the percent composition by mass of chlorine in  $\text{PCl}_{3(\text{l})}$  (gram-formula mass = 137 g/mol).

The diagram below shows the first three steps in the uranium-238 radioactive decay series.



The decay mode for the first and third steps is shown above the arrows. The decay mode for the second step is not shown in the diagram. Thorium-234 has a half-life of 24.10 days.

63 Explain, in terms of neutrons and protons, why U-238 and U-234 are different isotopes of uranium. [1]

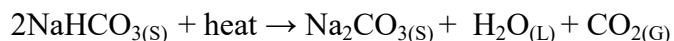
64 Identify the decay mode particle emitted from the Th-234. [1]

65 Determine the total time that must elapse until only one-sixteenth of an original sample of Th-234 remains unchanged.

Tetrachloroethene,  $\text{C}_2\text{Cl}_4$ , is a solvent used in many dry cleaning processes.

66 Write the empirical formula for tetrachloroethene

Thermal energy is absorbed as chemical reactions occur during the process of baking muffins. The batter for muffins often contains baking soda,  $\text{NaHCO}_{3(\text{s})}$ , which decomposes as the muffins are baked in an oven at  $200.^{\circ}\text{C}$ . The balanced equation below represents this reaction, which releases  $\text{CO}_{2(\text{g})}$  and causes the muffins to rise as they bake. The  $\text{H}_2\text{O}_{(\text{l})}$  is released into the air of the oven as it becomes a vapor.



67 Based on Table E, identify the polyatomic ion in the solid product of the reaction.

68 State the direction of heat flow between the air in the oven and the muffin batter when the muffin batter is first placed in the preheated oven at  $200.^{\circ}\text{C}$ .

69 Compare the potential energy of the liquid water molecules to the potential energy of the water vapor molecules.

A bubble of air at the bottom of a lake rises to the surface of the lake. Data for the air inside the bubble at the bottom of the lake and at the surface of the lake are listed in the table below.

**Data for the Air Inside the Bubble**

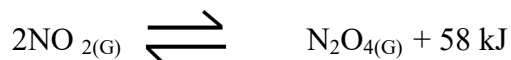
Location in Lake	Temperature (K)	Pressure (kPa)	Volume (mL)	Density (g/mL)
surface	293	104.0	2.5	0.0012
bottom	282	618.3	?	—

70 State the number of significant figures used to express the pressure at the surface of the lake.

71 Show a numerical setup for calculating the volume of the bubble at the bottom of the lake.

72 Determine the mass of the air in the bubble at the surface of the lake.

Nitrogen dioxide,  $\text{NO}_2$ , is a dark brown gas that is used to make nitric acid and to bleach flour. Nitrogen dioxide has a boiling point of 294 K at 101.3 kPa. In a rigid cylinder with a movable piston, nitrogen dioxide can be in equilibrium with colorless dinitrogen tetroxide,  $\text{N}_2\text{O}_4$ . This equilibrium is represented by the equation below.



73 State evidence from the equation that the forward reaction is exothermic.

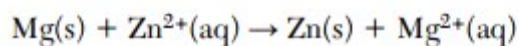
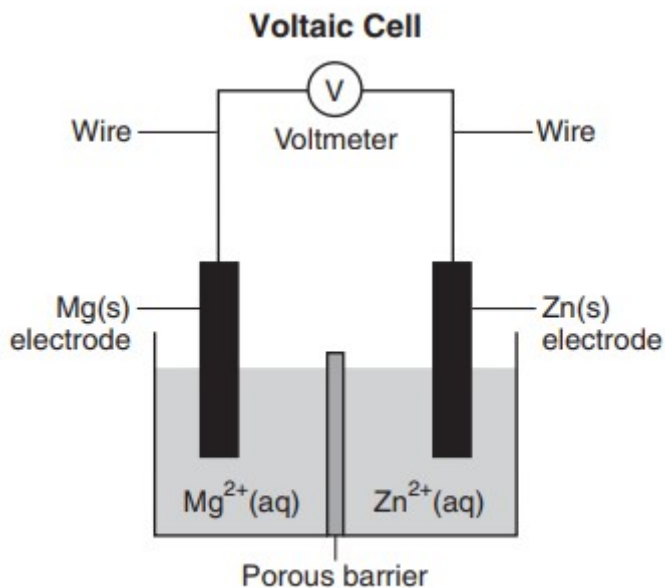
74 Compare the rate of the forward reaction to the rate of the reverse reaction when the system has reached equilibrium.

75 State one stress, other than adding or removing  $\text{NO}_{2(\text{G})}$  or  $\text{N}_2\text{O}_{4(\text{G})}$ , that would increase the amount of the dark brown gas.

76 At standard pressure, compare the strength of intermolecular forces in  $\text{NO}_{2(\text{G})}$  to the strength of intermolecular forces in  $\text{N}_2(\text{G})$ .

77 Determine the oxidation state of nitrogen in nitrogen dioxide.

A student sets up a voltaic cell using magnesium and zinc electrodes. The porous barrier in the cell has the same purpose as a salt bridge. The diagram and the ionic equation below represent this operating cell.



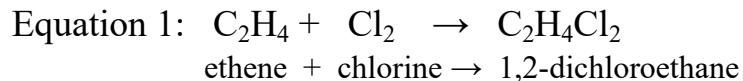
78 Determine the number of moles of  $\text{Mg}^{+2}_{(\text{AQ})}$  ions produced when 2.5 moles of  $\text{Zn}^{+2}_{(\text{AQ})}$  react completely in this cell.

79 State, in terms of ions, how the porous barrier functions as a salt bridge in this cell.

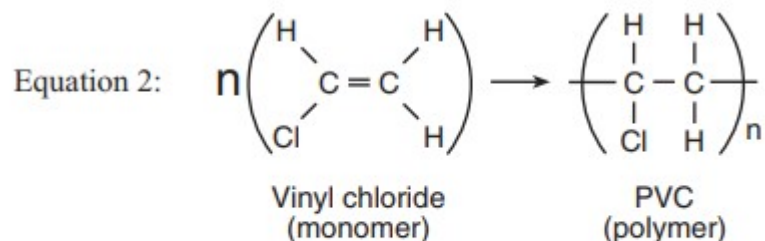
80 State, in terms of the relative activity of metals, why the reaction in this cell occurs.

81 Write a balanced half-reaction equation for the oxidation that occurs in this operating cell.

Polyvinyl chloride (PVC) is a polymer used to make drain pipes, flooring, electric wire insulation, and some plastic bottles. Making PVC requires several reactions. The first step is represented by the equation below.



The 1,2-dichloroethane is converted to vinyl chloride. To produce PVC, the vinyl chloride monomer is polymerized, as represented by the equation below



**Note:**  $n$  and  $n$  represent the same large number in the equation.

82 Explain, in terms of chemical bonds, why the hydrocarbon in equation 1 is unsaturated.

83 Identify the class of organic compounds to which the product of equation 1 belongs.

84 Draw a structural formula for the product of equation 1.

85 State the number of electrons shared between the carbon atoms in a molecule of vinyl chloride.