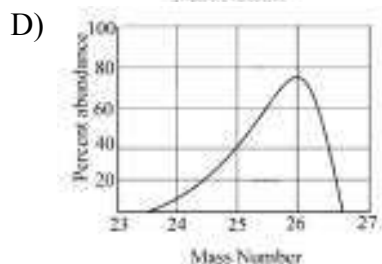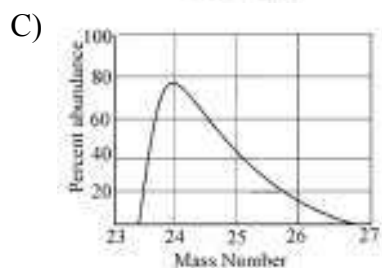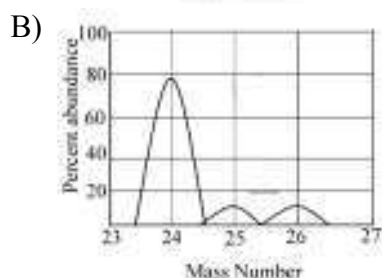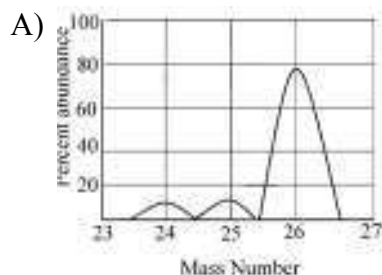1. Naturally occurring boron consists of two isotopes, boron–10 and boron–11. If the atomic mass of natural boron is 10.8, what is the percentage that is boron–10?

   A) 0%   B) 20%   C) 50%   D) 80%   E) 100%

2. Which mass spectrometer graph represents naturally occurring magnesium?

   A)

   B)

   C)

   D)

3. Which supports the conclusion that the energy of electrons in atoms are quantized?

   A) Mass spectrometer beam distribution
   B) Emission spectra of gaseous elements
   C) Cathode ray deflection by a magnetic field
   D) Scattering of alpha particles by metal foil
   E) Radioactive transmutation of elements

4. An ion which has the electron configuration [[Rn] $5f^{14}$] $^{2-}$ has the symbol

   A) Rn   B) Ra   C) Fm   D) Md   E) No

5. When a chloride solution of an element is vaporized in a flame, the color of the flame is purple. What element could be in the solution?

   A) Barium   B) Sodium
   C) Potassium   D) Lithium
   E) Calcium

6. What would be the most likely electron configuration for a Vanadium 2+ ion?

   A) $[Ar]4s^23d^3$ B) $[Ar]3d^3$
   C) $[Ar]4s^23d^1$ D) $[Ar]4s^13d^2$
   E) $[Ar]3d^5$

7. Base your answer to the following question on the following atomic orbitals.

   (A) $1s^2\,2s^1\,2p^1$ (B) $1s^2\,2s^2\,2p^1$ (C) $1s^2\,2s^2\,2p^6$ (D) [Ar] $4s^2$
   (E) [Ar] $4s^2\,3d^4$

   This atom is in an excited state.

   A) A   B) B   C) C   D) D   E) E

   Base your answers to questions **8** through **11** on the following electron configurations

   (A) $[Xe]\,4f^{14}5d^{10}6s^2$ (B) $[Kr]\,4d^{10}5s^1$ (C) $[Ar]\,3d^{10}4s^24p^5$ (D) $[Ar]$
   (E) $[Ne]\,3s^23p^2$

8. The configuration of a metallic diatomic element

   A) A   B) B   C) C   D) D   E) E

9. The configuration of a metalloid

   A) A   B) B   C) C   D) D   E) E

10. A common ion of an alkali metal

   A) A   B) B   C) C   D) D   E) E

11. The ground state of a halogen

   A) A   B) B   C) C   D) D   E) E

12. Which of the following elements will present a paramagnetic electron configuration?

   A) Zinc   B) Cadmium
   C) Calcium   D) Cobalt
   E) Magnesium

13. Which transition element has its d-orbitals completely filled?

    A) Fe   B) Cd   C) W   D) In   E) As

14. A fluorine atom (F) differs from a fluorine ion (F^-) in that the ion

    A) has more occupied subshells
    B) has less stability
    C) has greater nuclear charge
    D) has higher electronegativity
    E) has a larger radius

15. In a solution of which salt do all ions have the same electron configuration?

    A) NaBr   B) KF   C) $CaCl_2$ D) MgI_2 E) LiCl

    Base your answers to questions **17** through **21** on the choices below.

      (A) Pauli exclusion principle
      (B) Heisenberg uncertainty principle
      (C) Hund's rule
      (D) Wave nature of matter
      (E) Photoelectric effect

16. Which gives support to the particle theory of light?

    A) A   B) B   C) C   D) D   E) E

17. Which predicts that an oxygen atom in the ground state is paramagnetic.

    A) A   B) B   C) C   D) D   E) E

18. Which is responsible for interference patterns being exhibited by electrons?

    A) A   B) B   C) C   D) D   E) E

19. Which states that you cannot have simultaneous knowledge of an electron's position and momentum?

    A) A   B) B   C) C   D) D   E) E

20. Which states that electrons half fill an orbital with parallel spin, before completely filling it?

    A) A   B) B   C) C   D) D   E) E

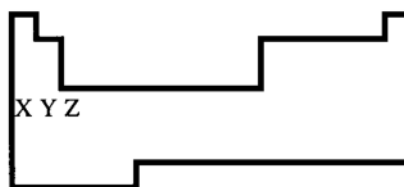21. Elements 'X', 'Y' and 'Z' have these atomic radii, in nanometers.

X	Y	Z
0.072 nm	0.099 nm	0.111 nm

    When atomic radii are correctly arranged, how might these elements appear in the periodic table?

A)

B)

C)

D)

23. **Ionization Potentials for element Z(eV)**

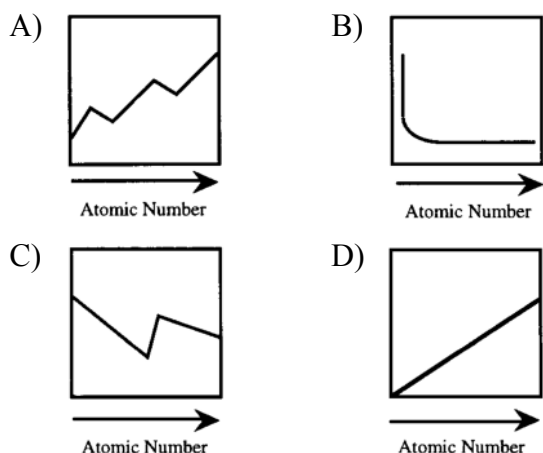| First	Second	Third	Fourth	Fifth
4.341	31.625	45.72	60.91	82.66

Based on the ionization potentials for element Z above, which of the following would most likely be element Z?

A) Sr B) K C) F D) Mg E) O

---

24. Whose theory of the atom is best supported by the experimental evidence shown in a graph of first ionization energy of the elements versus atomic number?

A) Moseley B) John Dalton
C) Ernest Rutherford D) J. J. Thompson
E) Niels Bohr

25. Which graph best depicts the relationship between the ionization energy and atomic number from left to right in a period?

A)
Atomic Number

B)
Atomic Number

C)
Atomic Number

D)
Atomic Number

27.

Ionization Energies (kJ/mol^{-1})					
First	Second	Third	Fourth	Fifth	Sixth
786	1577	3232	4355	16091	19784

Based on the ionization energies listed above, the element is most likely

A) Sb B) Ca C) Si D) Ga E) Se

28. **Ionization Energies (kJ/mol^{-1})**

First	Second	Third	Fourth
737.7	1450.6	7732.6	10540

Based on the ionization energies listed above, the element is most likely

A) Magnesium B) Potassium
C) Boron D) Silicon
E) Nitrogen

26.

IE$_1$	IE$_2$	IE$_3$	IE$_4$
630 kJ •mol^{-1}	1,680 kJ •mol^{-1}	25,040 kJ •mol^{-1}	126,000 kJ •mol^{-1}

The chart is a Periodic Table with only fourteen main group elements.

Aa					Bb
Cc	Dd	Ee	Ff	Gg	Hh
Ii	Jj	Kk	Ll	Mm	Nn

Which element would have this sequence of ionization energies?

A) Ii B) Jj C) Kk D) Mm E) Nn

29. Base your answer to the following question on the compounds below.

      (A) Carbon dioxide
      (B) Carbon monoxide
      (C) Water
      (D) Sodium chloride
      (E) Xenon pentafluoride

Which compound has the greatest lattice energy?

A) A   B) B   C) C   D) D   E) E

30. Which atom has the lowest second ionization energy?

A) Be   B) Na   C) K   D) Ar   E) Mg

31. Base your answer to the following question on the following elements.

      (A) Sodium
      (B) Carbon
      (C) Cobalt
      (D) Chlorine
      (E) Neon

Has the highest first ionization energy

A) A   B) B   C) C   D) D   E) E

32. Which of the following is true about the upper right hand corner of the periodic table?

A) High electron affinities, high ionization energies, high metallic character
B) High electron affinities, low ionization energies, low metallic character
C) High electron affinities, high ionization energies, low metallic character
D) Low electron affinities, high ionization energies, low metallic character
E) Low electron affinities, low ionization energies, low metallic character

33.

Physical Property	L	M	Q	R
MP (°C)	-7	63	-189	1083
BP (°C)	58	766	-186	2582
Color at STP	Dark red	Silvery	Colorless	Brown-red
Density at STP(g cm^{-3})	3.1	0.86	1.7×10^{-3}	8.9

Based on the above table, match these elements, in the order L, M, Q and R, to their respective groups in the periodic table.

A) L - group I   M - transition elements
    Q - group VII   R - group VIII

B) L - group VII   M - group I
    Q - group VIII   R - transition elements

C) L - group VII   M - transition elements
    Q - group VIII   R - group I

D) L - transition elements M - group I
    Q - group VII   R - group VIII

E) L - transition elements M - group VIII
    Q - group I   R - group VII

---

34. Copper has an oxidation number of +1 in

A) CuO   B) CuBr

C) CuS   D) CuC_2O_4

E) $Cu(CH_3COO)_2$

35. How many atoms are in 1 molecule of calcium hexacyanoferrate (II)?

A) 7   B) 8   C) 14   D) 15   E) 27

36. Base your answer to the following question on the elements below.

    (A) Fr
    (B) Sr
    (C) Br
    (D) Sb
    (E) H

Which forms monatomic ions of charge 2+ in solution?

A) A   B) B   C) C   D) D   E) E

37. A balloon filled with 0.01 mol of hydrogen gas is kept constant at 25 degrees Celcius. If the pressure is changed from 1 atm to 1.5 atm, what is the resulting volume of the balloon?

A) 0.12 L   B) 0.15 L
C) 0.25 L   D) 0.27 L
E) 0.30 L

38. $$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$$

A 0.03 mol sample of C_3H_8 is reacted with just enough O_2 to use up both reactants in a 1 L flask at 300 K. The total pressure in the flask after the reaction is complete is closest to which of the following?
(Use R = 0.082 L atm mol^{-1} K^{-1})

A) 5.0   B) 0.5   C) 0.1   D) 0.25   E) 0.05

39. A CH_4 (molar mass 16 grams) effuses at 0.080 mole per minute at 289 K. At that temperature, a gas that effuses at approximately double that rate has what molar mass?

A) 4 grams   B) 8 grams
C) 16 grams   D) 32 grams
E) 64 grams

41.

Volume of bag	1.60 Liters
Density of air	$1.20 \text{ g} \cdot \text{L}^{-1}$
Apparent weight of the gas	0.90 grams

A plastic bag is massed. It is then filled with a gas which is insoluble in water and massed again. The apparent weight of the gas is the difference between these two masses. The gas is squeezed out of the bag to determine its volume by the displacement of water. What is the actual weight of the gas?

A) 0.90 g   B) 1.02 g   C) 1.92 g   D) 2.82 g   E) 3.90 g

42.

Mass of magnesium reacted	0.079 g
Volume of hydrogen collected	73.2 mL
Atmospheric pressure	810. mmHg
Vapor pressure of water at 25°C	23.8 mmHg
Room temperature	298 K

The graph table above shows what happens when one mole of magnesium reacts with acid to produce one mole of H_2 (g).

What is the molar volume of H_2 at 760 mmHg and 298 K using this data?

A) 22.4 L   B) 23.3 L
C) 25.4 L   D) 36.6 L
E) 46.6 L

43. A 1.00 L container at 460. K contains 3.23 moles of argon gas. What is the pressure of the gas?

A) 1.24×10^4 atm   B) 194. atm
C)   122. atm   D) 244. atm
E) 87.0 atm

44. 1.00 gram of propene gas occupies what volume at 147. °C and 1.00 atm?

A) 0.821 L   B) 0.082 L
C)   0.420 L   D) 0.41L
E) 1.64 L

45. A gas has a density of 0.600 g/L at a pressure of 0.1642 atm and a temperature of 127.°C. What is the molar mass of the gas?

A) 60.0 g/mol   B) 120. g/mol
C)   240. g/mol   D) 360. g/mol
E) 480. g/mol

46. The temperature of a sample of H_2O is decreased. Which of the following can be true?

A) Volume constant, pressure increased, density constant
B) Volume constant, pressure decreased, density constant
C) Volume constant, pressure constant, density constant
D) Volume decreased, pressure constant, density increased
E) Volume decreased, pressure increased, density decreased

47. Which of the following gases is most like ideal?

A) He   B) SO_2 C) H_2O D)   CO   E) Br_2

48. Under what conditions do gases deviate the most from ideal behavior?

A) High temperature, low pressure
B) Low temperature, low pressure
C) Low temperature, high pressure
D) High pressure only
E) High temperature only

49. $2 \text{ Li} + 2 \text{ H}_2\text{O} \rightarrow 2 \text{ Li}^+ + 2 \text{ OH}^- + \text{H}_2$

When 0.800 mol of Li is reacted with excess water at STP in the equation above, what volume of hydrogen gas is produced?

A) 2.24 L   B) 4.48 L
C)   6.72 L   D) 8.96 L
E) 17.92 L

50. In 1811 Avogadro calculated the formula of camphor by means of elemental chemical analysis and by measuring the density of its vapor. Avogadro found the density to be 3.84 g/L when he made the measurements at 210°C at 1 atmosphere pressure. Which of the following is the correct formula for camphor?

A) $C_{10}H_{14}O$ B) $C_{10}H_{16}O$
C) $C_{10}H_{16}O_2$ D) $C_{10}H_{18}O$
E) none of the above

51. The pressure on a sample of gas is increased from 100 kPa to 130 kPa at constant temperature. Which of the following increases?

      I.   The density of the gas
      II.   The average distance between molecules
      III.   The average speed of the molecules.

A) I only   B) III only
C) I and III only   D) I and II only
E) I, II, and III

52. A 2.70 L sample of nitrogen gas is kept at a pressure of 800. torr and 27.0ºC. what would its volume be if the pressure was increased to 1200. torr and it was cooled to −73.0ºC.

A) 1.35 L   B) 1.80 L
C) 2.70 L   D) 3.60 L
E) 1.2 L

53. Two containers for gases are at the same temperature and pressure. One contains 14.0 grams of nitrogen and the other 2.0 grams of helium. Which of the following is true?

A) The volumes of the containers are the same.
B) Both containers contain the same number of atoms.
C) The average speed of the particles in both containers is the same.
D) The density of the containers is the same.
E) The size of the helium atoms is the same as the size of the oxygen atoms.

54. When a sample of ethane gas in a closed container is cooled so that its absolute temperature halves, which of the following also halves?

A) The average kinetic energy of the gas molecules
B) The potential energy of the gas molecules
C) The density of the gas
D) The volume of the gas
E) The number of molecules in the gas

55. A sample of gas in a closed container is raised to double its initial pressure while remaining at constant temperature. Which of the following occurs?

A) The volume of the gas doubles.
B) The density of the gas doubles.
C) The density of the gas halves.
D) The average kinetic energy of the molecules doubles.
E) The size of the molecules doubles.

56. A student collected a sample of gas using water displacement. Which of the following measurements is necessary to determine the vapor pressure of the water in the sample?

A) The volume of the gas
B) The kinetic energy of the gas
C) The volume of the water
D) The temperature of the water
E) The water solubility of the gas

57. Equal numbers of moles of $H_2O(g)$, $F_2(g)$, $Cl_2(g)$ are placed into a single container. The container has a pinhole-sized leak (1 mm), and after 10 minutes some gas has escaped from the container. What is best reason for why there is more Cl_2 gas left in the container than any other gas? (NOTE: the molecules do not react with each other)

A) The Cl_2 molecule is too big to escape through the leak-hole
B) The rate of effusion for Cl_2 is less than than that of the other two gases
C) Cl_2 is a nonpolar molecule
D) Cl_2 has the smallest S^o of the three gases
E) H_2O has the greatest rate of diffusion

58. $BCl_3NH_3 \rightarrow BCl_3 + NH_3$

A student places 0.10 mole of BCl_3NH_3 in a 1 L vacuum flask, which is sealed and heated. The BCl_3NH_3 decomposes completely according to the balanced equation above. If the flask's temperature is 375. K, the total pressure in the flask is closest to which of the following? (Use R = 0.08 L•atm/mol•K)

A) 6.0 atm   B) 1.5 atm
C) 3.0 atm   D) 4.5 atm
E) 7.5 atm

59. Base your answer to the following question on
$$C_3H_7OH\,(s) \rightarrow H_2O(g) + C_3H_6\,(g)$$
A student places 0.05 mole of C_3H_7OH (s) in a 1 L vacuum flask, which is sealed and heated. The propanol decomposes completely according to the balanced equation above. If the flask's temperature is 500. K, the total pressure in the flask is closest to which of the following? (Use R = 0.08 L•atm/mol•K)

A) 8.0 atm   B) 50. atm
C) 25. atm   D) 2.0 atm
E) 4.0 atm

60. A sealed metal tank is filled with neon gas. Which of the following does NOT occur when neon gas is pumped into the tank at a constant temperature?

A) The average speed of the neon atoms remains the same.
B) The density of neon gas inside the tank increases.
C) The average distance between molecules decreases.
D) The volume of the gas decreases.
E) The pressure inside the tank increases.

61. Find the partial pressure of Hydrogen gas collected over water at 18°C if the the vapor pressure of water at 18°C is 15.5 torr, and the total pressure of the sample is 745 torr.

A) 760.5 torr   B) 745.0 torr
C) 15.5 torr   D) 727.0 torr
E) 729.5 torr

62. Hydrogen gas is collected over water at 29°C. The total pressure of the system is 773 torr. If the vapor pressure of water at 29°C is 30 torr, what is the partial pressure of the hydrogen gas?

A) 803 torr   B) 30 torr
C) 743 torr   D) 753 torr
E) 773 torr

63. Base your answer to the following question on the following types of energy.

    (A) Lattice energy
    (B) Potential energy
    (C) Kinetic energy
    (D) Electromagnetic energy
    (E) Vaporization energy

Energy that is measured by $\frac{1}{2}mv^2$

A) A   B) B   C) C   D) D   E) E

64. A rigid cylinder is filled with gas. At constant temperature, which of the following applies to the gas in the cylinder when gas is released?

A) The average kinetic energy of the gas particles increases.
B) The pressure of the gas increases.
C) The volume of the gas decreases.
D) The total number of gas molecules stays constant.
E) The total force of the gas molecules hitting the side of the container decreases.

65. The temperature of a sample of xenon atoms is raised from 50°C to 90°C. Which of the following statements is true about the average kinetic energy of the atoms?

A) The average kinetic energy does not change.
B) The average kinetic energy of the sample increased by a factor of 363/323.
C) The average kinetic energy of the sample increased by a factor of 9/5.
D) The average kinetic energy increased by a factor of 81/25.
E) More information is needed to know whether the average kinetic energy changed.

66. The pressure of a real gas is sometimes less than that predicted by the ideal gas law because the ideal gas law does not include the factor of

A) mass of molecules
B) shape of molecules
C) intermolecular forces
D) size of molecules
E) energy of molecules

67. Under which conditions does a real gas most closely approximate an ideal gas?

A) Low pressure and low temperature
B) Low pressure and high temperature
C) High pressure and high temperature
D) High pressure and low density
E) Low temperature and high density

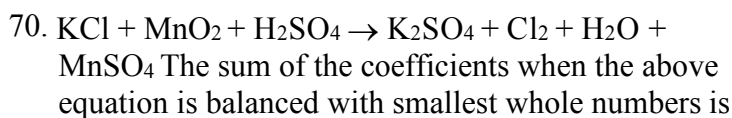68. $\_I_2 + \_F_2 \rightarrow \_IF_x$
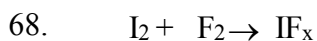
The above reaction occurs in a closed container. The container is rigid and temperature is constant throughout the reaction. The container starts out with 10 atm of iodine gas and 1 atm of fluorine gas. Five atm of iodine gas is left at the end of the reaction. What is x?

A) 1   B) 2   C) 3   D) 5   E) 7

69. $\_Al + \_Fe_3O_4 \rightarrow \_Fe + \_Al_2O_3$
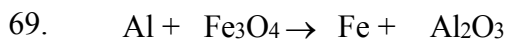
    When the above equation is balanced and all the coefficients are simplified to the lowest whole-number terms, what is the sum of all the coefficients?

    A) 15   B) 22   C) 24   D) 25   E) 28

70. $KCl + MnO_2 + H_2SO_4 \rightarrow K_2SO_4 + Cl_2 + H_2O + MnSO_4$ The sum of the coefficients when the above equation is balanced with smallest whole numbers is

    A) 8   B) 9   C) 10   D) 14   E) 18

71. $\_CH_3CH_2CHO + O_2 \rightarrow CO_2 + H_2O$

    The sum of coefficients when the above equation is balanced with smallest whole numbers is

    A) 10   B) 11   C) 12   D) 13   E) 14

72. What is the correct formula for iron (III) sulfate?

    A) Fe_2S_3 B) $FeSO_4$
    C) $FeSO_3$ D) $Fe_2(SO_4)_3$
    E) $Fe(SO_4)_3$

73. Which compound is correctly named?

    A) Fe_2O_3, iron(II) oxide
    B) H_2SO_4, sulfuric acid
    C) $AgNO_3$, silver nitride
    D) $MgSO_3$, magnesium sulfate
    E) KCl, potassium chlorate

74. $\_C_2H_4 + \_O_2 \rightarrow \_CO_2 + \_H_2O$
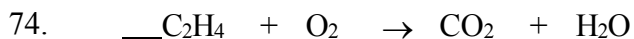
    When the above equation is balanced using smallest whole numbers, what is the coefficient of the O_2?

    A) 1   B) 2   C) 3   D) 4   E) 5

75. An aqueous solution of HCl is 25% water. What is the mole fraction of HCl?

    A) 14%   B) 0.14   C) 0.17   D) 0.25   E) 0.86

77. A 1.0 L test beaker is filled to the mark with 0.20 mol of KCl and 0.40 mol of $BaCl_2$. What is the minimum number of moles of $Pb(ClO_4)_2$ that are needed to precipitate out all of the Cl in the form of $PbCl_2$? ($PbCl_2$ is insoluble for the purposes of this question)

    A) 0.30 mol   B) 0.40 mol
    C) 0.50 mol   D) 0.60 mol
    E) 0.80 mol

78.

Element	Percent by Mass
C	40.0%
H	6.7%
O	53.3%

An element composed of C, H, and O with mass percentages corresponding to the above table. What most likely is the subscript under C if it a mole of the compound weighs 90 grams?

    A) 1   B) 2   C) 3   D) 4   E) 5

79. What volume of water should be added to a 200.0 mL solution of 4.00 M HI to create a 0.500 molar solution of HI?

    A) 1.40×10^3 mL   B) 14.0 L
    C) 1.40 mL   D) 14.0×10^3 mL
    E) 140. mL

80. What volume of water should be added to a 50.0 mL solution of 8.00 M NaOH to create a 2.50 molar solution of NaOH?

    A) 160 mL   B) 110 mL
    C) 320 mL   D) 210 mL
    E) 1.60 L

81. A 1.00 L flask contains an aqueous solution. The solution consists of 0.70 moles of KBr and 0.20 moles of $AlBr_3$. What is the minimum number of moles of $AgNO_3$ that can be added to the solution to precipitate all of the Br^- ions as AgBr?

    A) 0.90 moles   B) 1.30 moles
    C) 1.10 moles   D) 1.50 moles
    E) 0.70 moles

82. How many grams of carbonic acid, H_2CO_3, contains 32.00 grams of hydrogen atoms?

    A) 1055. g   B) 992.0 g
    C) 547.2 g   D) 346.5 g
    E) 241.0 g

83. How many grams of sodium nitrate, $NaNO_3$, contains 96.0 grams of oxygen atoms?

    A) 170.   B) 165.   C) 140.   D) 125.   E) 115.

84. The Mond process produces pure nickel metal via the thermal decomposition of nickel tetracarbonyl as shown in the equation below.

    $$Ni(CO)_4(l) \rightarrow Ni(s) + 4CO(g)$$

    How many liters of CO would be formed from 444 g of $Ni(CO)_4$ at 752 mm Hg and 22ºC?

    A) 0.356 L   B) 63.7 L
    C) 255 L   D) 20.2 L
    E) 11.0 L

85. A compound of bromine combined with tungsten is found to contain 68.5 % bromine and 31.5% tungsten. What is the empirical formula for this compound?

    A) WBr_2 B) WBr_3 C) WBr_4 D) WBr_5 E) WBr_6

86.

	Ca	C	O
1	38%	40%	22%
2	40%	12%	48%
3	45%	15%	40%
4	50%	10%	40%
5	55%	5%	40%

Above is a table of possible mass percentages for a compound of Ca, C, and O. Which set of percentages matches the compound $CaCO_3$?

A) 1   B) 2   C) 3   D) 4   E) 5

87. The formula of copper (II) sulfate pentahydrate is

    A) $CuSO_4$ B) $CuSO_4 \cdot 3H_2O$
    C) $CuSO_4 \cdot 2H_2O$ D) $CuSO_4 \cdot 6H_2O$
    E) $CuSO_4 \cdot 5H_2O$

88. The formula of barium peroxide is

    A) BaO B) BaO_2
    C) Ba_2O D) Ba_2O_2
    E) BaO_4

89. The set of formulas that are all correct is

    A) FeS, $CuCl$, $CuCl_3$
    B) H_2O, $HClO$, CaS_2
    C) Pb_2O_5, HBr, K_3NO_3
    D) $FeCl_3$, MgS, $NaHCO_3$
    E) $CaBr$, $CaSO_4$, $AlPO_3$

90. The correct formula for manganese (IV) oxide is

    A) Mn_4O B) MnO_2
    C) MnO_4 D) Mn_2O
    E) MnO

91. Which is the correct formula for silver phosphite?

    A) $Ag_3(PO_4)_4$ B) Ag_3PO_4
    C) $Ag_3(PO_3)_2$ D) $Ag_3(PO_4)_2$
    E) Ag_3PO_3

92. The formula for sodium thiosulfate is

    A) Na_2SO_3 B) Na_2SO_4
    C) $Na_2S_3O_2$ D) $Na_2S_2O_3$

93. The set which contains three correct formulas is

    A) $Al_2(SO_4)_3$, MgI, KCl
    B) $Ag(OH)_2$, $NaOH$, ZnO_3
    C) $MgBr_2$, Na_2SO_4, $Zn(OH)_2$
    D) $Ca_3(PO_4)_2$, $Al_2(SO_4)_3$, $Ag(OH)_3$
    E) CaI, $NaNO_3$, $BaSO_4$

94. Which set of formula contains an *incorrect* formula?

    A) $LiClO_4$, $NaCN$, $Ca_3(PO_4)_2$
    B) $KClO$, H_2SO_4, $PbCl_2$
    C) $Fe_2(CO_3)_3$, H_2O_2, AgI
    D) $Ca(HCO_3)_2$, $CuBr$, $CuBr_2$
    E) HCl, $NaCO_3$, Br_2

95. The name of a chemical compound ds in "*ide*"; the compound is

    A) acidic   B) basic
   C) binary   D) an oxide
    E) a solid

96. The name of $Na_2CO_3 \cdot 10H_2O$ is

    A) sodium carbonate hydrate
    B) sodium carbonate decahydrate
    C) disodium carbonite decahydrate
    D) disodium carbonate heptahydrate
    E) sodium carbonite decahydrate

97. The name corresponding to the formula $Fe(H_2PO_3)_2$ is

    A) iron (II) biphosphite
    B) iron (II) biphosphate
    C) iron (III) biphosphite
    D) iron (III) dihydrogen phosphate
    E) iron (III) biphosphate

98. Which acid is followed by the correct name of the salt it forms?

    A) chlorous acid → chlorite
    B) sulfurous acid → sulfate
    C) nitrous acid → nitrate
    D) carbonic acid → carbide
    E) sulfuric acid → sulfite

99. Which compound is correctly named?

    A) $PbCO_3$ → lead (IV) carbonate
    B) Cu_2SO_4 → copper (I) bisulfate
    C) $Fe(ClO_2)_3$ → iron (III) chlorite
    D) Mn_2S_4 → manganese (II) sulfide
    E) TiO_2 → titanium (III) oxide → titanium

100. MN_2 M_2P QP
    Determine the formula expected for a compound of hypothetical elements Q and N, using only the formulas above.

    A) QN B) QN_2 C) Q_2N_3 D) QN_4 E) Q_2N

101. Platinum metal is reacted with fluorine gas. The resulting compound is found to be 83.7% Pt, and and 16.3% F by mass. What is the empirical formula of this compound?

    A) PtF_4 B) PtF_6 C) PtF_2 D) Pt_2F_8 E) Pt_2F_{10}

102. The first chemical compound of a noble gas element was prepared in 1962. Since then several such compounds have been prepared and characterized. What is the empirical formula of a compound of Xe which is 67.2% Xe and 32.8 % O by mass?

    A) XeO_2 B) XeO_3
    C) XeO_4 D) XeO_5
    E) Xe_2O_5

103. Analysis of a quantity of a compound shows that it contains 0.110 mol of C, 0.055 mol of N, and 0.165 mol of O. Its molecular weight is about 270. How many atoms of carbon are there in the empirical formula for the compound and how many in the molecular formula?

    A) Empirical, 1; molecular, 3
    B) Empirical, 2; molecular, 2
    C) Empirical, 2; molecular, 6
    D) Empirical, 3; molecular, 2
    E) Empirical, 2; molecular, 3

104. Base your answer to the following question on
    $$2\ C_6H_6 + 15\ O_2 \rightarrow 12\ CO_2 + 6\ H_2O$$
    Based on the above equation, how many moles of O_2 are needed to produce 18 moles of water and 30 moles of carbon dioxide?

    A)   15   B)   30   C)   37.5 D)   45   E) 60

105. $\_Fe_2O_3 + \_C \rightarrow \_Fe + \_CO_2$

    Using a balanced equation, find the mass of Fe produced with excess carbon and 1.5 moles of Fe_2O_3.

    A)   27.93   B) 55.85
    C)   83.76   D) 167.55
    E) 111.70

106. $2\ MnO_4 + 5\ H_2C_2O_4 + 3\ H_2SO_4 \rightarrow$
    $2\ MnSO_4 + 10\ CO_2 + 8\ H_2O + K_2SO_4$
    According to the equation above, how many moles of MnO_4 would be necessary to produce 20.0 moles of CO_2, starting with 25.0 moles of $H_2C_2O_4$?

    A) 4.00 moles   B) 25.0 moles
    C)   20.0 moles   D) 2.00 moles
    E) 8.00 moles

107. $K_2Cr_2O_7 + 14HCl \rightarrow 3Cl_2 + 7H_2O + 2CrCl_3 + 2KCl$
    According to the equation above, how many moles of HCl would be necessary to produce 6.0 moles of $CrCl_3$, starting with 4.0 moles of $K_2Cr_2O_7$?

    A) 6.0   moles   B) 42. moles
    C)   14. moles   D) 2.0 moles
    E) 28. moles

108. $C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$
    Based on the above unbalanced chemical equation, one gram of octane will yield what mass of water?

    A) 0.079 g   B) 1.4 g
    C)   18 g   D) 162 g
    E) 0.158 g

109. $2 NO (g) + O_2 (g) \rightarrow 2 NO_2 (g)$
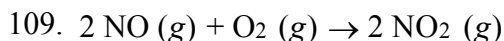
A mixture containing 0.30 mol NO and 0.30 mol O_2 reacts in a 1.0 L flask at a constant temperature of 20°C. What is the pressure in the flask when the reaction is complete?

A) (0.60)(0.082)(293) atm
B) (0.45)(0.082)(293) atm
C) (0.30)(0.082)(293) atm
D) (0.60)(0.082)(20) atm
E) (0.45)(0.082)(20) atm

110. $4 HF (g) + SiO_2 (s) \rightarrow SiF_4 (g) + 2 H_2O (l)$
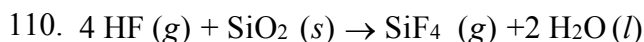
If 10. g of HF (formula mass 20. g/mol) reacts with 15. g of SiO_2 (formula mass 60. g/mol), how much water is produced?

A) 2.3 g B) 4.5 g C) 9.0 g D) 18. g E) 36. g

111. An experiment was conducted to determine the rate law of the reaction $2 A + 2 B \rightarrow C + D$. The data collected is shown below.

Experiment	Initial [A]	Initial [B]	Initial rate of reaction
1	2.00 M	2.00 M	4.00×10^{-4}
2	4.00 M	2.00 M	1.60×10^{-3}
3	2.00 M	1.00 M	1.00×10^{-4}

What is the rate law for this equation?

A) k = [A][B]   B) k = [A]²[B]
C) k = [A][B]²   D) k = [A]²[B]²
E) k = [A][B]²

112. A first order reaction goes to half completion in 79 hours. What is the rate constant for this reaction?

A) 7.9 × 10⁻³ h⁻¹   B) 8.77 × 10⁻³ h⁻¹
C) 79 h   D) 39.5 h
E) 4.39 × 10⁻³ h⁻¹

113. Base your answer to the following question on the possible rate laws below for the reaction:
$A + B \rightarrow C$

$(A) Rate = k[B]^2$
$(B) Rate = k[B][A]$
$(C) Rate = k[B]^2[A]$
$(D) Rate = k[B][A]^2$
$(E) Rate = k[B]^2[A]^2$

When [A] is tripled and [B] is constant then the initial rate of reaction remains constant.

A) A   B) B   C) C   D) D   E) E

114. $A + 2 B \rightarrow 2 C + 4 D$
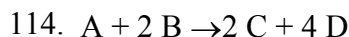
The rate law for the above reaction is

A) $[C]^2[D]^4$
B) $k[C]^2[D]^4$
C) second order
D) first order
E) impossible to find without experimental data

115.

Experimental	$[H_2]$ (mol/L)	Initial [ICl] (mol/L)	Initial Rate of Reaction (mol/s•L)
1	.30	.20	3.0×10^{-3}
2	.30	.60	9.0×10^{-3}
3	.10	.60	1.0×10^{-3}

The above chart contains experimental data obtained from the following reaction:

$H_2 + 2 ICl \rightarrow I_2 + 2 HCl$
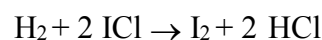
What is the experimental rate law for this reaction?

A) Rate = $k[H_2]/[ICl]$
B) Rate = $k[H_2][ICl]$
C) Rate = $k[H_2][ICl]^2$
D) Rate = $k[H_2]^2[ICl]^2$
E) Rate = $k[H_2]^2[ICl]$

116. Given the reaction:

$Cl_2(l) + 2 Na(s) \rightarrow 2 NaCl(s)$
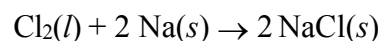
The reaction rate can be significantly increased by:

A) cooling the system
B) adding more sodium, Na
C) increasing the volume of the system
D) removing sodium chloride, NaCl
E) using gaseous chlorine, Cl_2

117. The temperature of a reaction is increased from 350 K to 400 K. The reaction rate is tripled. Which of the following equations can be used to find the activation energy of the reaction?

A) the Drake equation
B) the Clausius-Claperon Equation
C) the Arrhenius equation
D) the Nernst equation

E) Avogadro's equation

Base your answers to questions **118** and **119** on on the table below, for the following reaction:

$2 SO_2 + O_2 \rightarrow 2 SO_3$
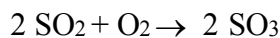
Experiment	$[SO_2]$	$[O_2]$	Rate
1	1.00 M	0.50 M	2.0×10^{-8} M/s
2	1.00 M	0.25 M	1.0×10^{-8} M/s
3	2.00 M	0.50 M	8.0×10^{-8} M/s

118. The value of the rate constant, k, for this reaction is

A) 4.0×10^{-8} B) 2.0×10^{-8} C) 1.0×10^{-8} D) 4.0×10^{-9} E) 2.0×10^{-9}

119. What is the experimental rate law for the reaction above?

A) Rate $= k[SO_2][O_2]^3$ B) Rate $= k[SO_2]^3[O_2]^2$
C) Rate $= k[SO_2][O_2]$ D) Rate $= k[SO_2]^3[O_2]$
E) Rate $= k[SO_2]^3$

Base your answers to questions **120** and **121** on the table of data for the following reaction:

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$
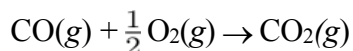
Experiment	$[CO]$	$[O_2]$	Rate
1	0.50 M	0.50 M	2.0×10^{-5} M/s
2	0.25 M	0.50 M	0.50×10^{-5} M/s
3	0.25 M	1.0 M	1.0×10^{-5} M/s

120. The value of the rate constant, k, is

A) 1.6×10^{-4} M/s B) 8.0×10^{-5} M/s C) 4.0×10^{-5} M/s D) 1.0×10^{-5} M/s E) 3.2×10^{-4} M/s

121. When $[CO] = [O_2] = 1.0$ M, the rate of reaction will be

A) 2.0×10^{-5} M/s B) 1.6×10^{-4} M/s C) 1.0×10^{-5} M/s D) 0.50×10^{-5} M/s E) 8.0×10^{-5} M/s

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122. A student collected the initial-rate data in the chart below.

Experiment	Initial [XO] (mol/L)	Initial [O₂] (mol/L)	Initial rate of formation of XO₂ [mol/(L·s)]
1	0.20	0.20	0.40
2	0.80	0.20	6.4
3	0.20	0.40	0.80

What is the experimental rate law for this reaction?

A) rate $= k [XO]^2[O_2]^{-1}$
B) rate $= k [XO][O_2]^{-1}$
C) rate $= k [XO]^2 [O_2]$
D) rate $= k [XO] [O_2]^2$
E) rate $= k [XO]^2 [O_2]^2$

123. For which of the following rate laws would the graph of ln [Z] versus time be a straight line?

A) rate $= k$ B) rate $= k [Z]$
C) rate $= k [Z]^2$ D) rate $= [Z]$
E) rate $= [Z]^2$

124. Consider the following factors:

I. Reactant particles collide
II. Sufficient kinetic energy is present
III. A favorable geometry exists
IV. Catalysts are present

Which combination of the above factors is required for all successful collisions?

A) I only
B) II and III only
C) I and III only
D) I, II, III and IV
E) I, II and III only

125. When solid AgBr is added to saturated solution of AgBr, the reaction rates can be described as

A) rate of dissolving increases; rate of crystallization increases
B) rate of dissolving decreases; rate of crystallization increases
C) rate of dissolving increases; rate of crystallization decreases
D) rate of dissolving decreases; rate of crystallization decreases
E) rate of dissolving remains constant; rate of crystallization decreases

Base your answers to questions **126** through **128** on the rate law given below for the reaction $A + B + C \rightarrow D$.

$$Rate = k[A]^2[B][C]$$

126. What is the order of the reaction with respect to A?

A) 1   B) 2   C) 3   D) 4   E) 0

127. If the concentration of B is decreased, what will happen?

A) Both [A] and [C] will increase.
B) Both [A] and [C] will decrease.
C) [A] will decrease and [C] will increase.
D) [A] will increase and [C] will decrease.
E) Both [A] and [C] will stay the same.

128. If the concentration of C is doubled what will happen?

A) The rate of the reaction increases
B) The rate of the reaction decreases
C) The value of the equilibrium constant increases
D) The value of the equilibrium constant decreases
E) Neither the equilibrium constant nor the rate would change.

129. Base your answer to the following question on the table below which was obtained for the reaction $A + B \rightarrow C$.

Experiment	Initial [A] (mol L^{-1})	Initial [B] (mol L^{-1})	Initial rate of formation of C (mol L^{-1} min^{-1})
1	0.10	0.20	6.0×10^{-2}
2	0.20	0.20	6.0×10^{-2}
3	0.10	0.40	2.4×10^{-1}

What is the rate law for this reaction?

A) Rate = $k[A]^2$
B) Rate = $k[B]^2$
C) Rate = $k[A][B]$
D) Rate = $k[A]^2[B]$
E) Rate = $k[A][B]^2$

130.   I. $Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$
     II. $4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$

Which statement best describes the relative rates of the above two reactions?

A) I is faster than II
B) II is faster than I
C) I and II are both fast
D) I and II are both slow
E) The relative rates of reaction cannot be determined

131.   I. $4\ Al(s) + 3\ O_2(g) \rightarrow 2\ Al_2O_3(s)$
     II. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

Which statement best describes the relative rates of the above two reactions?

A) I is faster than II
B) II is faster than I
C) I and II are both fast
D) I and II are both slow
E) The relative rates of reaction cannot be determined

132. Which of the following is not correlated with a fast reaction rate?

    I. Catalysts
    II. High temperature
    III. High concentration of reactants
    IV. Strong bonds in the products
    V. Low level of activation energy

A) I and II only
B) I, II, and IV only
C) III, IV, and V only
D) IV and V only
E) They are all correlated with a fast reaction rate

133. Base your answer to the following question on the graph below which shows the number of molecules with a given kinetic energy plotted as a function of kinetic energy. Four catalysts are available, A, B, C and D, which have associated reaction activation energies E_A, E_B, E_C, and E_D respectively.
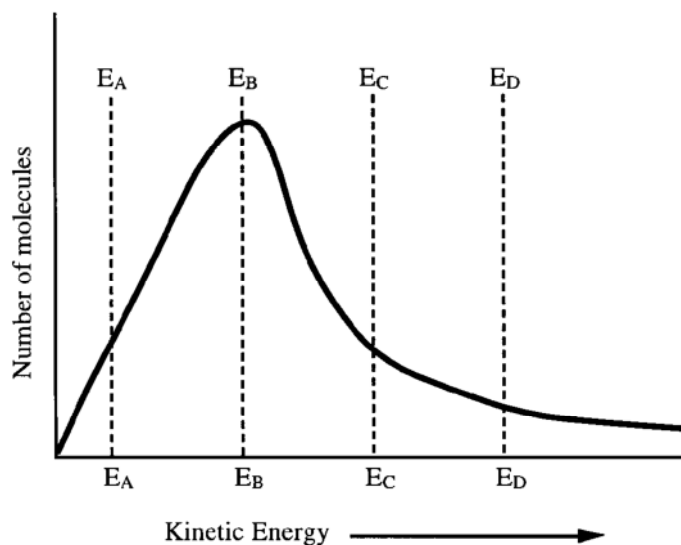
Which catalyst will have an activation energy which will result in the *slowest reaction rate* ?

A) Catalyst 'A' associated with energy E_a
B) Catalyst 'B' associated with energy E_b
C) Catalyst 'C' associated with energy E_c
D) Catalyst 'D' associated with energy E_d
E) The activation energies of catalysts A, B, C and D all result in the same reaction rate.

134. Base your answer to the following question on the graph below showing the energy during a catalyzed reaction.
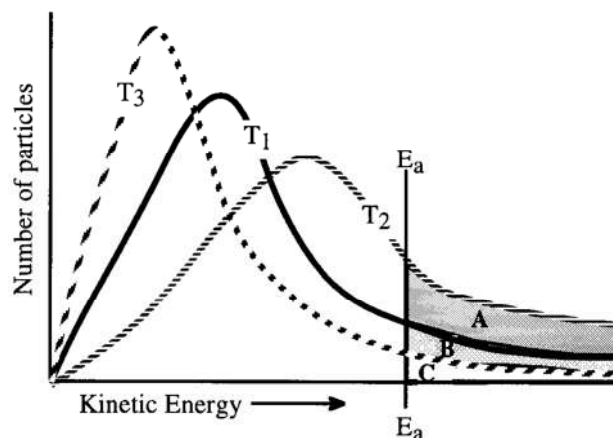
Which is the curve for the *lowest* temperature?

A) Curve T_1 B) Curve T_2
C) Curve T_3 D) Can't tell

135. Generally an increase of ten degrees centigrade doubles the rate of reaction between gases. The explanation for this increase in reaction rate is the doubling of the

A) concentration of the reactants
B) average kinetic energy of the molecules
C) number of intermolecular collisions per unit of time
D) number of particles with an energy above a minimum activation energy
E) voulume of the reactants

136. Base your answer to the following question on the following reaction.

$$H_2(g) + I_2(g) \leftrightarrow 2\ HI(g)$$
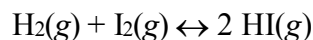
The reaction above is allowed to reach equilibrium. The pressure on the system is doubled. Which of the following is true?

A) [H_2] will increase. B) [I_2] will increase.
C) [HI] will decrease. D) 1 and 2
E) None of these

137. Which of the following reactions is slowest at room temperature?

A) $Zn(s) + S(s) \rightarrow ZnS(s)$
B) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$
C) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$
D) $2\ Ag^+(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$
E) $NaCl(aq) \rightarrow Na^+(aq) + Cl^-(aq)$

Base your answers to questions **138** and **139** on the diagram shown below.

Reaction Coordinate
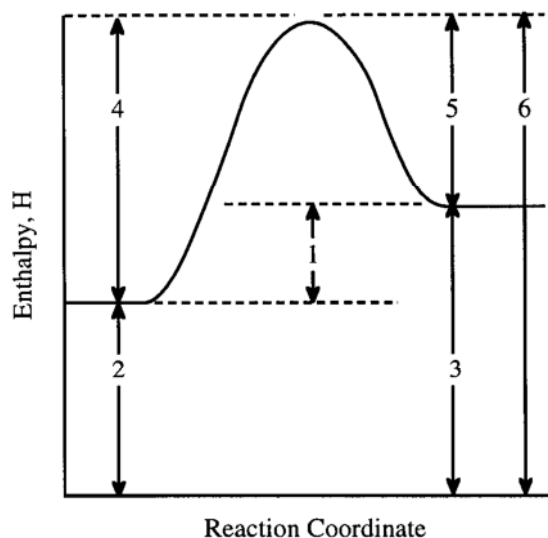
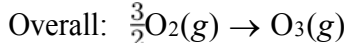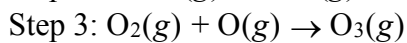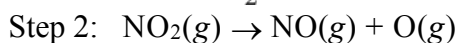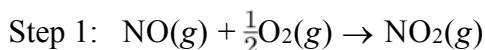138. Which represents the activation energy for the forward reaction?

    A) 1   B) 2   C) 3   D) 4   E) 6

139. A catalyst would change

    A) 1 and 6   B) 2 and 3
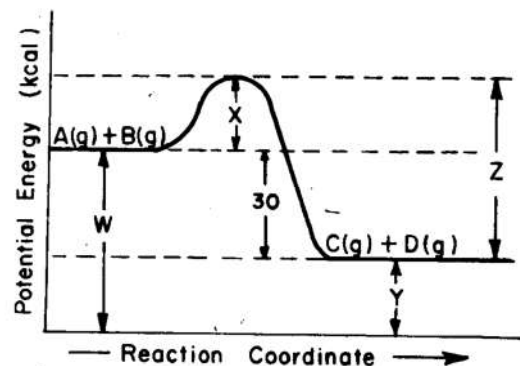   C) 3 and 4   D) 4, 5 and 6
    E) 3 and 6

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140. The reaction mechanism for the production of ozone, O_3, from automotive exhaust occurs in the three steps below.

    Step 1: $NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g)$
    Step 2: $NO_2(g) \rightarrow NO(g) + O(g)$
    Step 3: $O_2(g) + O(g) \rightarrow O_3(g)$
    Overall: $\frac{3}{2}O_2(g) \rightarrow O_3(g)$

    Which species is the catalyst?

    A) $O(g)$ B) $O_2(g)$
    C) $O_3(g)$ D) $NO_2(g)$
    E) $NO(g)$

141.

— Reaction Coordinate ⟶
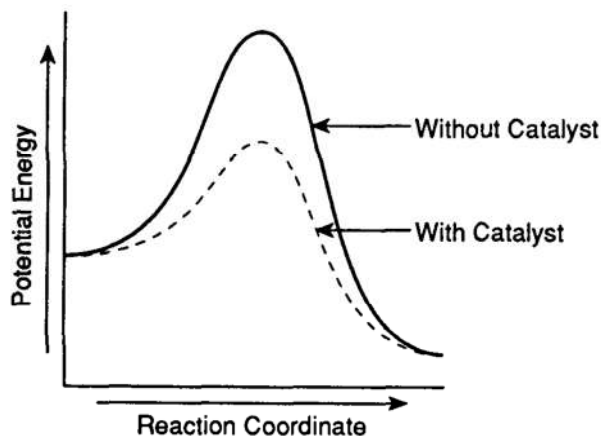
According to the above reaction mechanism, the distanced marked "Z" represents

A) the activation energy for $A(g) + B(g) \leftrightarrow C(g) + D(g)$

B) the heat of reaction for for $A(g) + B(g) \leftrightarrow C(g) + D(g)$

C) the activation energy for $C(g) + D(g) \leftrightarrow A(g) + B(g)$

D) the heat of reaction for $C(g) + D(g) \leftrightarrow A(g) + B(g)$

E) none of these

142.

Reaction Coordinate

Which of the following is the best explanation of the graph above?

A) The addition of the catalyst increases the potential energy of the reaction.

B) The catalyst makes the reaction proceed in the forward direction ONLY.

C) The addition of a catalyst lowers the activation energy of the reaction.

D) The catalyst is consumed by the reaction, and produces extra energy.

E) The catalyst slows down the speed of reaction.

143.
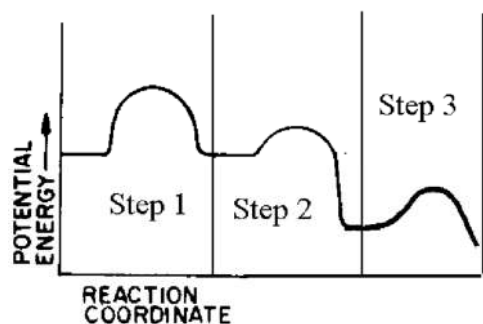
According to the above chart, which of the following is the correct justification for why one of the three steps is the rate determining step?

A) Step 2, because it has the lowest activation energy

B) Step 1, because it has the highest activation energy

C) Step 1, because it is neither endothermic nor exothermic

D) Step 2, because it is the most exothermic

E) Step 3, because it is the least exothermic

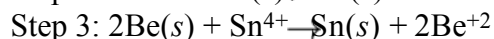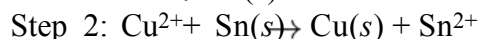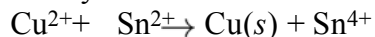144. A catalyst increases the rate of a chemical reaction by

A) increasing the kinetic energy

B) decreasing the heat of reaction

C) changing the concentration of the reactants

D) providing an alternate reaction mechanism

E) decreasing kinetic energy

145. $CO + NO_2 \rightarrow CO_2 + NO$ $\Delta H = -234$ kJ

The activation energy of the forward reaction represented by the above equation is 134. kJ. What is the activation energy for the reverse reaction?

A) −134. kJ   B) −100. kJ

C) 422. kJ   D) 234. kJ

E) 368. kJ

146. Base your answer to the following question on Step 1:
$Cu^{2+} + Sn^{2+} \rightarrow Cu(s) + Sn^{4+}$
Step 2: $Cu^{2+} + Sn(s) \rightarrow Cu(s) + Sn^{2+}$
Step 3: $2Be(s) + Sn^{4+} \rightarrow Sn(s) + 2Be^{+2}$

In the above proposed reaction mechanism, what would be the products of the overall catalyzed reaction?

A) Sn^{2+} and Be^{+2} B) Sn^{4+} and Sn^{2+}

C) $Sn(s)$ and Sn^{4+} D) Cu^{2+} and $Cu(s)$

E) $Cu(s)$ and Be^{+2}

147.

Step	Species Being Produced	Rate of Production
(A) 1	B	0.0020 $\frac{mol}{h \bullet mol_A}$
(B) 2	C	0.030 $\frac{mol}{h \bullet mol_B}$
(C) 3	D	0.011 $\frac{mol}{h \bullet mol_C}$
(D) 4	E	0.42 $\frac{mol}{h \bullet mol_D}$

Which is the rate–determining step in the above hypothetical reaction mechanism?

A) A

B) B

C) C

D) D

E) the rate determining step cannot be determined

148.
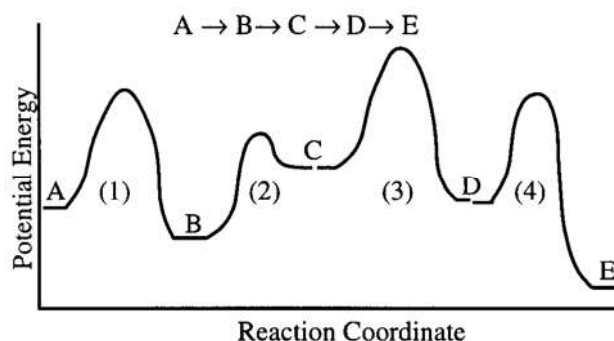
Which is the "rate determining step" for the above hypothetical reaction mechanism of the overall reaction $A \rightarrow E$?

A) step 1

B) step 2

C) step 3

D) step 4

E) the rate determining step cannot be determined

149. In a reaction mechanism, the rate determining state is the

A) fastest and has the lowest activation energy

B) fastest and has the highest activation energy

C) slowest and has the lowest activation energy

D) slowest and has the highest activation energy

E) intermediate and has the lowest activation energy

150. Step 1: $Cl(g) + O_3(g) \rightarrow ClO(g) + O_2(g)$
Step 2: $O(g) + ClO(g) \rightarrow Cl(g) + O_2(g)$
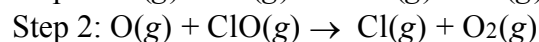
According to the above reaction mechanism, the reaction intermediate is

A) Cl   B) O_2 C) O_3 D) ClO   E) O

151. Base your answer to the following question on the reaction below.

$$2\,A(g) + B(s) \leftrightarrow 3\,C(g); \ \Delta H < 0$$

If the rate expression for this reaction does not depend on B, what could be the cause of this?

A) B is not involved in any steps in this reaction.
B) B is not involved in the rate determining step, but may be involved in other steps in the reaction.
C) The coefficient of B is 1, therefore it does not affect the rate of the reaction.
D) B is a solid, therefore does not appear in the rate expression.
E) The order of the reaction with respect to B is 1.

152. Which compound dissolves in water to form a clear solution?

A) $CrCl_2$ B) $LiCl$
C) $FeCl_3$ D) $CoCl_2$
E) $NiCl_2$

153. Base your answer to the following question on the elements below.

(A) Fluorine
(B) Copper
(C) Phosphorous
(D) Neon
(E) Francium

Which element is a highly reactive metal?

A) A   B) B   C) C   D) D   E) E

154. All the following statements concerning the alkali metals are true EXCEPT:

A) Francium is the least electronegative.
B) They form ions with 1+ charge.
C) Lithium has the smallest atomic radius.
D) First ionization energy increases with atomic number.
E) They are not found in pure form in nature.

155. When a solution of strontium chloride is ignited, the color of the flame is

A) blue   B) orange
C) purple   D) red
E) green

156. An element has lst, 2nd and 3rd ionization energies given in kJ mol^{-1}.

IE_1	IE_2	IE_3
735	1,450	7,720

This element is a member of which group?

A) Alkali metals.
B) Transition elements.
C) Noble gases.
D) Halogens.
E) Alkaline earth metals.

Base your answers to questions **157** through **160** on the electron configurations below.

(A) **2**s^1
(B) [Ar] **3**d^{10}**4**s^2**4**p^1
(C) [Kr] **4**d^{10}**5**s^2**5**p^3
(D) [Ne] **3**s^2
(E) [Kr] **4**d^{10}**5**s^2**5**p^6

157. An atom with three valence electrons

A) A   B) B   C) C   D) D   E) E

158. An atom in an excited state

A) A   B) B   C) C   D) D   E) E

159. Represents a noble gas

A) A   B) B   C) C   D) D   E) E

160. An alkaline earth metal

A) A   B) B   C) C   D) D   E) E

161. A soluble magnesium salt is

A) $MgSO_3$ B) $MgCO_3$
C) $Mg(OH)_2$ D) $Mg(NO_3)_2$
E) $Mg_3(PO_4)_2$

162. Base your answer to the following question on the elements below.

(A) Boron
(B) Rubidium
(C) Nitrogen
(D) Mercury
(E) Plutonium

Usually exists as a diatomic gaseous element

A) A   B) B   C) C   D) D   E) E

163. Which of the following is true about the halogens?

    A) Fluorine is the least electronegative element.
    B) Bromine liberates free chlorine from a solution of chloride ions.
    C) Ionization energy increases with increasing atomic number.
    D) Fluorine has the smallest atomic radius.
    E) They combine with Group I metals to form compounds of the form XY_2.

164. Which of the following is true about the halogen family?

    A) Its valence electrons are of the form ns^2np^4.
    B) Atomic radius decreases with increasing atomic number.
    C) It combines with group IIA metals in binary compounds of the form XY.
    D) It contains members that naturally exist in each of the 3 states of matter.
    E) All its members are monatomic.

    .

165. Base your answer to the following question on the chemicals below.

    (A) Sulfur dioxide
    (B) Hydrochloric acid
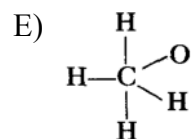   (C) Water
    (D) Potassium phosphate
   (E) Copper chloride

    Which forms a colored solution in water?

    A) A   B) B   C) C   D) D   E) E

166. Which of the following is FALSE about elemental carbon?

    A) Carbon has oxides that can be acid anhydrides.
    B) Diamond is an example of elemental carbon in the solid state.
    C) Nearly all organic compounds contain carbon.
    D) The AMU is defined as 1/12 of the weight of a carbon-12 atom.
    E) Since carbon is located between a metal and a nonmetal, it is classified as metalloid.

167. Which of the following is an acid?

    A)

    B)

    C)

    D)

    E)
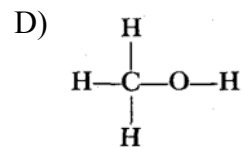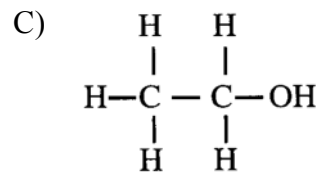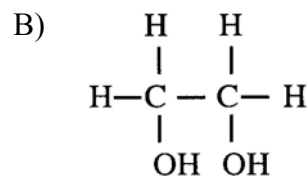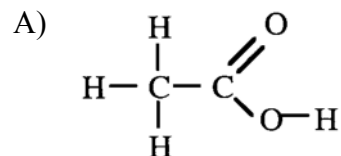
173. A student wishes to prepare approximately 1.00 liter of a 0.200 m $MgCl_2$ solution (formula mass 95.0 g). The proper procedure would be to weigh out

    A) 19.0 g of $MgCl_2$ and 1.00 kg of water.
    B) 19.0 g of $MgCl_2$ and 989. g of water.
    C) 19.0 g of $MgCl_2$ and add water until final solution is approximately 1.00 liter.
    D) 95.0 g of $MgCl_2$ and 915. g of water.
    E) 95.0 g of $MgCl_2$ and 1.00 kg of water.

174. A student wishes to prepare 3.00 liters of a 0.100 M HCl solution (formula mass 36.0 g). The proper procedure is to weigh out

    A) 10.8 g of HCl and 1.00 kg of water.
    B) 10.8 g of HCl and add water until the final solution has a volume of 3.00 liters
    C) 36.0 g of HCl and add water until the final solution has a volume of 3.00 liter.
    D) 10.8 g of HCl and add 3.00 liter of water.
    E) 36.0 g of HCl and add 3.00 liter of water.

Base your answers to questions **179** and **180** on the following information.

312 grams of benzene gas (C_6H_6) is burned to completion with O_2 in a flame resistant giant balloon at 298 K. The balloon is held at a constant pressure of 5 atm. All liquid is allowed to flow out without the loss of any gas.

179. Determine the final volume of the balloon after the reaction is complete.

180. Write the balanced equation for the reaction.

181. Water is added to a 8.23 g sample of $TaCl_5$. The only products are 5.71g of a solid containing only tantalum, chlorine and oxygen and 3.35 g of a gas which is 97.2% chlorine and the remainder is hydrogen.

(a) Determine the empirical formula of the gas.
(b) What fraction of the chlorine of the original compound is in the solid?
(c) Determine the empirical formula for the solid produced.
(d) Write a balanced equation for the reaction between tantalum pentachloride and water.

182. Consider the data collected for the reaction $2 A + B \rightarrow C + D$.

Trial	Initial [A] (mol L^{-1})	Initial [B] (mol L^{-1})	Initial rate of Formation of C (mol L^{-1} min^{-1})
1	.100	.100	3.54×10^{-6}
2	.200	.100	1.42×10^{-5}
3	.100	.200	5.01×10^{-6}
4	.200	.400	2.84×10^{-5}

(a) Write down the rate law for the formation of C.
(b) Calculate the rate constant for the reaction, including the proper units.
(c) The following mechanism was proposed for the reaction. Show if it leads to the correct rate law.

Step 1: $A + \frac{1}{2} B \leftrightarrow X$ (fast equilibrium)
Step 2: $X + A \rightarrow C + Y$ (slow)
Step 3: $Y + \frac{1}{2} B \rightarrow D$ (fast)

(d) If the rate increases threefold as the temperature increases from 300. to 350. Kelvin, what is the activation energy for the reaction?

183. $2 A + 3 B \rightarrow C + D$

The following results were obtained by studying the reaction above at 40°C.

| Trial	Initial [A] (mol L^{-1})	Initial [B] (mol L^{-1})	Initial rate of Formation of C (mol L^{-1} min^{-1})
1	.15	.15	3.2×10^{-5}
2	.15	.45	2.9×10^{-4}
3	.30	.45	5.8×10^{-4}
4	?	.50	6.3×10^{-4}

(a) Determine the order of the reaction with respect to A and B. Justify your answer.
(b) Write the rate law for the reaction, and calculate the rate constant, specifying units.
(c) What is the inital rate of disappearance of B in trial 1?
(d) What is the initial concentration of A in trial 4?
(e) Write a possible 3 step reaction mechanism that is consistant with both the rate law and the stoichiometry of the reaction. Indicate which step is the rate determining step.

184. $2 \, SeO_2(g) + Cl_2(g) \rightarrow 2 \, SeO_2Cl(g)$
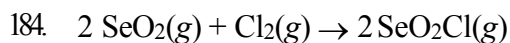
A kinetic study of the reaction above was conducted at 350K. The data obtained are shown in the table below.

Trial	Initial $[SeO_2]$ $(mol \, L^{-1})$	Initial $[Cl_2]$ $(mol \, L^{-1})$	Initial rate of formation of SeO_2 $(mol \, L^{-1} \, s^{-1})$
1	.0120	.0200	1.38×10^{-5}
2	.0120	.0100	2.76×10^{-5}
3	.00600	.0400	6.90×10^{-6}

(a) Calculate the initial rate of disappearance of $Cl_2(g)$ in trial 1.
(b) Write the expression for the rate law for this reaction.
(c) Calculate the specific rate constant, k, and specify its units
(d) The following mechanism was proposed for the reaction

$SeO_2(g) + Cl_2(g) \rightarrow 2 \, SeO_2Cl_2(g)$ (slow)
$SeO_2Cl_2(g) + SeO_2(g) \rightarrow 2 \, SeO_2Cl(g)$ (fast)
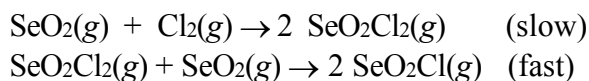
Is this mechanism consistent with the experimental observations; justify your answer.