Wizard Test Maker

AP CHEMISTRY

QUESTION CATALOGUE

eduware

AP Chemistry

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II. States of Matter

III. Reactions

1657.

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

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1. 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 (D) D
(B) B **(E) E**
(C) C

1165. Which atom has the lowest second ionization energy?

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

1182. 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 **(D) D**
(B) B (E) E
(C) C

1355. If you start at Fr and end at Li in Group 1A of the periodic table, what general trend is observed?

(A) Increasing metallic characteristics
(B) Decreasing electron affinities
(C) Decreasing ionization energies
(D) Decreasing atomic radii
(E) Increasing number of oxidation states

1332.

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 (D) Silicon
(B) Potassium (E) Nitrogen
(C) Boron

1333.

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

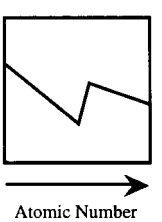
Based on the ionization energies listed above, the element is most likely

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

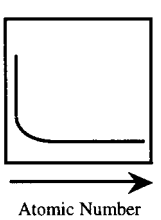
1661. Which graph best depicts the relationship between the ionization energy and atomic number from left to right in a period?

(A)

(C)



(B)



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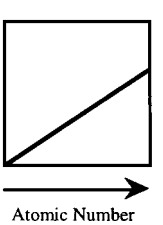


1283. The minimum amount of energy required to remove the most loosely held electron of an isolated gaseous atom.

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

Base your answers to questions **1292** through **1295** on the following substances (all solids).

(A) RbCl
(B) SiO_2
(C) Ag
(D) CN^-
(E) C_3H_8

1292. Held together by a lattice of positive and negative ions

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

1293. Electrons flow in a "sea" throughout the substance

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

1294. This substance has strong single covalent bonds, but weak intermolecular forces

(A) A (D) D
(B) B **(E) E**
(C) C

1295. Contains strong multiple covalent bonds

(A) A **(D) D**
(B) B (E) E
(C) C

1379. Which of the following is true about elemental carbon changing from a solid (diamond) to a gas?
$C(s) \rightarrow C(g)$

(A) The reaction must take place in an aqueous solution.
(B) The reaction occurs readily at STP.
(C) Covalent bonds are being broken.
(D) A network covalent solid is becoming an ionic gas.
(E) Heat is given off by the reaction.

1392. Which of the following has the lowest boiling point?

(A) SiO_2 **(D) C_2H_6**
(B) LiCl (E) Fe
(C) NH_3

Base your answers to questions **1393** through **1396** on the following bonding types.

(A) Coordinate covalent bonding
(B) Network covalent bonding
(C) Ionic bonding
(D) Metallic bonding
(E) Hydrogen bonding

1393. Type of bonding exhibited by two atoms with a large electronegativity difference

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

1394. Type of bonding that is exhibited by a substance acting as a Lewis base

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

1395. Substances with this bonding type exhibit good electrical and thermal conductivity

(A) A **(D) D**
(B) B (E) E
(C) C

1396. Bonding associated with nitrogen, oxygen and fluorine only

(A) A (D) D
(B) B **(E) E**
(C) C

1397. Which of the following atoms is most likely to disobey the octet rule?

(A) B (D) C
(B) O (E) F
(C) N

1713. A certain solid is insoluble in water, does not conduct electricity in either the solid or liquid state and melts at a temperature above 1500°C. Which type of bonding is most likely between lattice points in its crystalline structure?

(A) Ionic (D) Molecular covalent
(B) Metallic (E) Coordinate covalent
(C) Network covalent

82. Base your answer to the following question on the types of solids given below.

(A) A metallic solid
(B) A molecular solid with hydrogen bonds
(C) A molecular solid with non-polar molecules
(D) A network solid
(E) An ionic solid

Which generally has the lowest boiling point?

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

1040. Which of the following solutions will have the greatest electrical conductivity?

(A) 1.0 *M* HCN (D) 1.0 *M* CH_3COOH
(B) 1.0 *M* H_2SO_4 (E) 1.0 *M* NaCl
(C) 1.0 *M* H_3PO_4

1213. Although structural isomers C_3H_7OH and $C_2H_5OCH_3$ exhibit different properties, which of the following would be expected to be the same for both compounds?

(A) Heats of fusion **(D) Molecular masses**
(B) Melting points (E) Heats of vaporization
(C) Solubility constants

1250. Which of the following statements is true about elemental nitrogen?

(A) Nitrogen can form an oxide that is an acid anhydride.
(B) Nitrogen is a dark green gas at room temperature.
(C) Elemental nitrogen is diatomic; the two atoms are bonded together by a double covalent bond.
(D) Nitrogen is the second most prevalent gas in Earth's air.
(E) Nitrogen's only ion has a charge of +5.

1269. Which of the following exhibits coordinate covalent bonding?

(A) NH_3 (D) N_2O
(B) NH_4^+ (E) CN^-
(C) NO_3^-

1317. Why is the melting point of potassium chloride lower than that of magnesium oxide?

(A) The O^{2-} is more negatively charged than the Cl^- ion.
(B) The Cl^- ion is larger than the O^{2-} ion.
(C) The Mg^{2+} is more positively charged than the Na^+ ion.
(D) Choices A and C are correct.
(E) Choices B and C are correct.

1318. What is main reason the boiling point of methanol higher than the boiling point of methane?

(A) Methanol is a molecular compound.
(B) Methanol undergoes hydrogen bonding.
(C) Methane contains hydrogen bonding.
(D) Alcohols are always liquids at room temperatures.
(E) Methanol contains an oxygen atom.

1390. Which has the smallest force of attraction between its molecules?

(A) H_2 (D) C_2H_2
(B) NaCl (E) MgO
(C) I_2

1391. Which of the following substances has the highest boiling point?

(A) CH_3OCH_3 **(D) C_2H_5OH**
(B) C_6H_6 (E) CH_4
(C) C_4H_{10}

1406. Which of the following has the largest bond distance?

(A) CN^- (D) H_2O
(B) CO **(E) NH_3**
(C) CO_2

1407. Which of the following substances has the strongest bonds?

(A) N_2 (D) I_2
(B) O_2 (E) Hg_2^{2+}
(C) F_2

1414. Copper (II) oxide and silicon dioxide are both crystalline solids. What is the best explanation for why silicon dioxide has a much higher melting point than CuO?

(A) Copper is a metal and silicon is a metalloid.
(B) Copper dioxide has the greater dipole moment.
(C) Van der Waals forces are only important in CuO.
(D) SiO_2 is a network covalent solid.
(E) SiO_2 is a body centered lattice; CuO is a face centered lattice.

1415. Molecular solids

(A) melt at lower temperatures than ionic solids
(B) cannot sublime
(C) contain at least one hydrogen bond
(D) always contain multiple covalent bonds
(E) are packed tightly into a crystal lattice

1416. An example of a molecular compound that exists as a solid at STP is

(A) CO_2 (D) C_3H_8
(B) CH_4 **(E) SiC**
(C) C_2H_5OH

117. When ^{12}N decays by positron emission, it becomes?
(A) ^{13}N **(D) ^{12}C**
(B) ^{12}N (E) ^{8}B
(C) ^{13}C

118. Which of the following has the greatest mass?
(A) An alpha particle (D) A positron
(B) A beta particle (E) A hydrogen nucleus
(C) A gamma ray

119. Which of the following has a charge of +1?
(A) An alpha particle (D) A neutron
(B) A beta particle **(E) A deuteron**
(C) A gamma ray

125. The radioactive decay ^{3}H to ^{3}He occurs by the process of
(A) beta particle emission (D) gamma ray emission
(B) positron emission (E) gamma ray absorption
(C) alpha particle emission

126. Which form of radioactive decay results in a decrease of mass number?
(A) Beta particle emission **(D) Alpha particle emission**
(B) Positron emission (E) Gamma ray emission
(C) Electron capture

127. Which two processes result in the same change in the nucleus?
(A) Positron emission and beta particle emission
(B) Alpha particle emission and electron capture
(C) Alpha particle emission and beta particle emission
(D) Beta particle emission and electron capture
(E) Positron emission and electron capture

237. Which of the following statements is true about beta particles?

I. They are lighter than alpha particles.
II. They are positively charged.
III. They are electrons.

(A) I only (D) II and III
(B) III only **(E) I and III**
(C) I and II

238. What sort of radiation would be expected for $^{8}_{5}B$?
(A) alpha emission **(D) positron emission**
(B) beta emission (E) none, it is a stable nucleus
(C) gamma emission

303. The nuclide $^{140}_{56}Ba$ is radioactive and decays by loosing 1 beta (β^-) particle. The product formed is
(A) $^{140}_{55}Cs$ **(D) $^{140}_{57}La$**
(B) $^{140}_{56}Ba$ (E) $^{141}_{57}La$
(C) $^{141}_{56}Ba$

1120. What happens to the mass number and the atomic number of an element when it undergoes beta decay?
(A) Neither the mass number nor the atomic number change.
(B) The mass number does not change and the atomic number increases by 1.
(C) The mass number does not change and the atomic number decreases by 2.
(D) The mass number decreases by 4 and the atomic number decreases by 2.
(E) The mass number increases by 2 and the atomic number increases by 1.

1153. $^{232}_{90}Th$ is converted to $^{208}_{82}Pb$ by the emission of a series of alpha and beta particles. How many alpha and beta particles are emitted in the process?
(A) $\frac{\text{alpha}}{3}$ $\frac{\text{beta}}{2}$
(B) $\frac{\text{alpha}}{4}$ $\frac{\text{beta}}{2}$
(C) $\frac{\text{alpha}}{4}$ $\frac{\text{beta}}{8}$
(D) $\frac{\text{alpha}}{5}$ $\frac{\text{beta}}{2}$
(E) $\frac{\text{alpha}}{6}$ $\frac{\text{beta}}{4}$

1191. Which of the following choices correctly lists alpha particles, beta particles, and gamma rays in increasing energy?
(A) Alpha particles>beta particles>gamma rays
(B) Gamma rays>beta particles>alpha particles
(C) Alpha particles>gamma rays>beta particles
(D) Gamma rays>alpha particles>beta particles
(E) Beta particles>gamma rays>alpha particles

1950. $^{9}_{4}Be + X \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$

What kind of particle or radiation is Be bombarded with to cause it to emit a neutron?
(A) Gamma radiation (D) Neutrino
(B) Beta radiation (E) Positron
(C) Alpha radiation

465. Consider the tables below.

Compound	Melting point	Electrical conductivity in fused state (Ω^{-1})
CaF_2	1423	>20
$CaCl_2$	782	>20
CF_4	–50	0

Substance	Bond length (Å)
F_2	1.42
I_2	2.66
O_2	1.21

For each pair of elements listed, account for the difference in given properties as they relate to their atomic or molecular structure.

(a) CaF_2 and $CaCl_2$
(b) CaF_2 and CF_4
(c) O_2 and F_2
(d) F_2 and I_2

(a) CaF_2 has smaller ions than $CaCl_2$.
(b) CaF_2 has ionic bonds CF_4 has covalent bonds.
(c) F_2 has a single bond O_2 has a double bond.
(d) F_2 has smaller molecules than I_2.

467. ClO_2 ClO_2^+ ClO_2^-

Assume that chlorine is the central atom of each of the following species above.

(a) Draw the Lewis dot structure for each of the above species.

(b) List the species in order of decreasing bond angle and justify your answer.

(c) Identify the one species which would dimerize and justify your answer.

(b) $ClO_2^+ > ClO_2 > ClO_2^-$; due to an increase in number of electrons on central atom, taking up surface area (VSEPR).
(c) ClO_2; since it contains an odd number of electrons.

468. Use the principles of atomic structure and/or chemical bonding to explain each of the following.

(a) The radius of the K atom is 0.227 nm and the radius of the K^+ ion is 0.133 nm. Account for this difference.

(b) The lattice energy for MgO is –37954. kJ/mol, and the lattice energy for Na_2O is –2841. kJ/mol. Account for this difference.

(c) Explain why Mg has a higher first ionization energy than Na, but a lower second ionization energy.

(d) The first ionization energy of Be is 9.322 eV, the first ionization energy of B is 8.298 eV.

(a) K has an electron in the 3*s* sublevel, the ion does not. In addition the charge ratio is towards the positive, causing a contraction of the electon shells.
(b) The charges on the Mg^{2+} ion are greater than the charges on the Na^+ ion, leading to a higher lattice energy.
(c) For both Mg and Na, the first electron is removed from the 3s sublevel, and thus the greater nuclear charge on Mg gives it a higher first ionization energy. The second electron in Mg is also 3s, but in Na it is 2p, which is more tightly bound.
(d) In Be, the first valence electron is in a filled sublevel, and thus harder to remove.

96. 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

97. 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.

144. 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.

242. A sample of 0.0200 mol of chlorine gas is kept at 27.0ºC and 0.150 atm. What would be its pressure if the temperature was increased to 227.ºC and the volume kept the same
(A) 0.060 atm
(B) 0.250 atm
(C) 1.20 atm
(D) 2.10 atm
(E) 0.300 atm

243. 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

259. What is the density of a gass that has a molar mass of 336 g/mol at STP?
(A) 15 g/L
(B) 17 g/L
(C) 150 g/L
(D) 168 g/L
(E) 336 g/L

260. What is the density of oxygen gas at STP?
(A) 0.7 g/L
(B) 1.4 g/L
(C) 2.5 g/L
(D) 16. g/L
(E) 32. g/L

265. An ideal gas in a sealed container is heated from 290 K to 370 K at constant volume. Which of the following DO NOT change?

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 II only
(D) I and III only
(E) I, II, and III

266. 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.

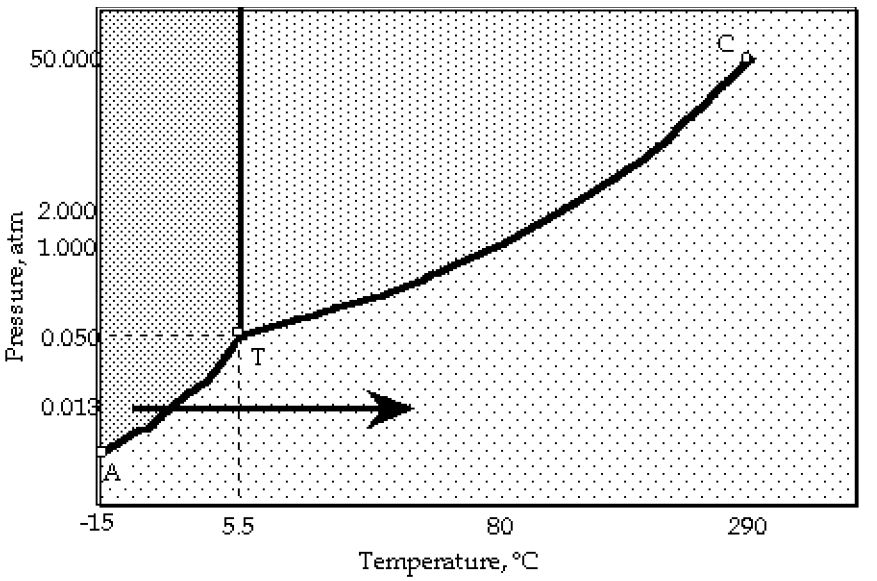
(A) I only
(B) III only
(C) I and III only
(D) I and II only
(E) I, II, and III

296. At 25ºC He gas (molar mass 4.00 grams) effuses at a rate of 0.100 mole per minute. What is the rate of effusion of O_2 (molar mass 32.0 grams)?
(A) 0.025 mole per minute
(B) 0.035 mole per minute
(C) 0.10 mole per minute
(D) 0.20 mole per minute
(E) 0.40 mole per minute

297. At 25.ºC, C_2H_6 (molar mass 30. g) effuses at a rate of 0.38 mole per minute. Which gas would have a rate of effusion approximately one-half as fast?
(A) He (molar mass 4.0 g)
(B) CH_4 (molar mass 16. g)
(C) NO (molar mass 30. g)
(D) N_2O_3 (molar mass 76. g)
(E) Cl_2O_3 (molar mass 119. g)

1362. Which of the following gases is most like ideal?
(A) He
(B) SO_2
(C) H_2O
(D) CO
(E) Br_2

Base your answers to questions **1278** through **1280** on this phase diagram.



1278. What is the normal boiling point of the substance on the graph above?
(A) 100°C **(B) 80°C** (C) 290°C (D) 5.5°C (E) –1.5°C

1279. The critical temperature of this substance is 290°C. What is meant by the term "critical temperature"?
(A) It is the temperature at which the substance can no longer exist.
(B) It is the temperature above which a substance can no longer be evaporated.
(C) It is the temperature above which a substance can no longer be liquified.
(D) It is the temperature above which a substance can no longer be solidified.
(E) It is the temperature at which all electrons enter the excited state.

1280. What information could you NOT learn from this diagram?
(A) The conditions needed for sublimation
(B) The relative densities of the three phases of this substance
(C) The critical pressure of the substance
(D) The latent heat of vaporization
(E) The triple point of the substance

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109. The pressure and temperature at which a substance is in equilibrium between solid, liquid and gas phases is known as the
(A) freezing point depression **(D) triple point**
(B) STP (E) normal boiling point
(C) osmotic pressure

110. The critical pressure of a substance is the
(A) pressure above which it cannot be liquified at any temperature
(B) pressure where the solid liquid and gas phases can coexist at equilibrium
(C) pressure that is present at absolute zero
(D) pressure at which the substance would boil at a constant temperature
(E) vapor pressure of the substance at 0°C

1196. In the phase diagram of water, graphing pressure versus temperature, why does the equilibrium between the solid and liquid phases curve to the left?
(A) The solid phase is more dense than the liquid phase.
(B) An increase in pressure causes the liquid to vaporize.
(C) The liquid phase is more dense than the solid phase.
(D) The liquid phase has a higher vapor pressure than the solid phase.
(E) At higher temperatures, the liquid is more likely to vaporize.

1419. Which cannot be determined from the typical triple point graph?
(A) The critical pressure
(B) The critical temperature
(C) The triple point
(D) Conditions needed for sublimation
(E) The heat of vaporization

56. Of the following organic compounds, which is LEAST soluble in water at 298 K?
(A) C_6H_6, benzene
(B) CH_3Cl, chloromethane
(C) C_2H_5OH, ethanol
(D) C_2H_5COOH, propanoic acid
(E) $C_5H_{10}O_5$, fructose

223. As temperature increases, solubility of which of the following decreases?
(A) NH_3
(B) NH_4Cl
(C) $NaNO_3$
(D) KCl
(E) KI

778. Which of the following dissolves in water to form an ionic solution?
(A) O_2
(B) SiO_2
(C) $KMnO_4$
(D) $C_{12}H_{22}O_{11}$
(E) CH_4

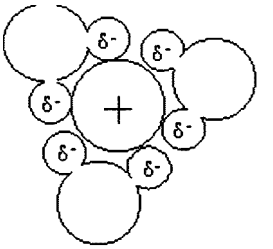
1541. The table below summarizes the result as 0.10 *M* solutions are mixed.

Solution	KCN	NaOH
$Cd(NO_3)_2$	no precipitate	precipitation occurs
$ZnCl_2$	precipitation occurs	precipitation occurs

Which substance is a precipitate in this experiment?
(A) KCl
(B) NaCN
(C) NaCl
(D) $Zn(NO_3)_2$
(E) $Cd(OH)_2$

1820. A clear, colorless liquid in a beaker in a hood is heated at a constant rate. The liquid begins to boil at 110°C. The boiling temperature gradually increases to 115°C, at which time the heating is discontinued. The material in the beaker is probably a
(A) pure element
(B) pure compound
(C) a colloid
(D) heterogeneous solution
(E) homogeneous solution

1937. Which compound has the highest conductivity?
(A) HF
(B) H_2O
(C) $CaSO_4$
(D) HNO_3
(E) $Pb(OH)_2$

1954. A solution of Na^+ ions would be best represented by which picture?
(A)


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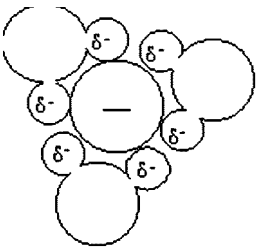

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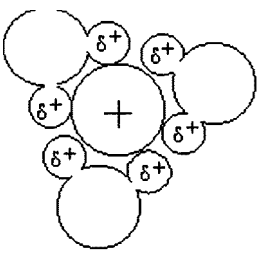

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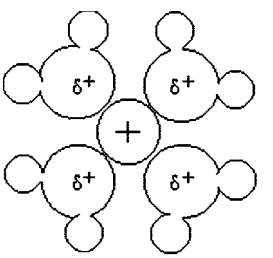

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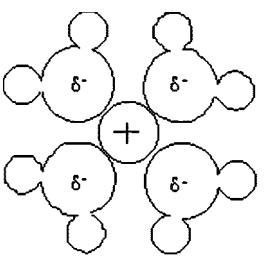

2093. 70 grams of a certain solute is dissolved in 100 grams of water, which has a freezing point depression of 1.858 K/m. The solution's freezing point is now 265.568 K. What is the molar mass of this solute?
(A) 123 g/mol
(B) 140 g/mol
(C) 167 g/mol
(D) 175 g/mol
(E) 200 g/mol

511. $K_2SO_3 + 2\ HCl \rightarrow 2\ KCl + H_2O + SO_2$

A 2.50 sample containing potassium sulfite and potassium iodide is analyzed by adding hydrochloric acid. The sulfur dioxide formed measured 320.0 mL when collected over water at 21ºC and a pressure of 804.1 mm Hg. What is the percent by mass of potassium sulfite in the original sample. (The vapor pressure of water at 21ºC is 18.7 mm Hg.)
86.7%

512. At 25ºC, the vapor pressure of formic acid is 43 torr and the vapor pressure of acetic acid is 35 torr.

(a) When 1.5 moles of a non-volatile non electrolyte is disolved in 30. moles of formic acid, what is the vapor pressure of the solution.
(b) A solution is made with 4.0 moles of acetic acid and 2.0 moles of formic acid.
(i) What is the vapor pressure of the solution at 25ºC
(ii) What is the percent of formic acid in the vapor
(a) 41 torr
(b) (i) 37.7 torr
(ii) 38%

514. A 5.67 gram sample of iodine heptaflouride is placed in a 3.0 liter evacuated flask and completely vaporized at 184ºC.

(a) If no reaction occurs, what is the pressure in the flask.
(b) Iodine heptaflouride decomposes acording to the reaction
$IF_7 \leftrightarrow IF_5 + F_2$
If the pressure in the flask is measured to be .50 atmospheres, what is the partial pressure of the IF_7 and the IF_5 at 184ºC.
(a) 0.273 atm
(b) IF_7 0.046 atm
IF_5 0.227 atm

515. (a) A 3.4 g sample of a liquid is completely vaporized at its boiling point of 20ºC and a pressure of 1200. torr. The resulting vapor has a volume of 240. milliliters. Assuming the gas is ideal, what is its molecular mass.

(b) At a temperature not far above the boiling point, the gas is not ideal. How does its actual molecular mass compare to that calculated in part (a)? Justify your answer.
(a) 216 g / mol
(b) The actual mass is lower. We have MM = mRT/PV, intermolecular forces make the product PV smaller and thus the calculated value too high.

516. (a) State two ways that real gases differ from ideal gases and how this affects the equation of state.
(b) Which of the following gases would have the greatest deviation from ideal behavior. Justify your answer.
F_2 CO_2 CH_4 N_2O_3
(c) Under what conditions of temperature and pressure do real gases most closely approximate ideal gasses?
(a)1. Real molecules have a finite volume. Thus making the actual volume greater than the ideal volume 2. Real gases experience IMF's thus making the real pressure less than the ideal pressure.
(b) N_2O_3 because it is the largest molecule and has the strongest intermolecular forces.
(c) Low pressure and high temperature.

518. Give a scientific explanation for each of the following observed pehnomena.

(a) A hydrogen filled balloon can lift more weight than a helium filled baloon of equal volume.

(b) When a baloon filled with gas is allowed to sit undisturbed, its volume slowly decreases.
(a) hydrogen is less dense than helium.
(b) The gas effuses through the walls of the balloon.

239. $H_2PO_4^- + H_2O \leftrightarrow HPO_4^{2-} + H_3O^+$

In the above equilibrium, which species act as acids?

I. $H_2PO_4^-$
II. H_3O^+
III. HPO_4^{2-}

(A) I only (B) II only **(C) I and II** (D) II and III (E) I and III

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57. Which of the following salts forms an aqueous solution with a pH less than 7?

(A) NaCl (D) NaF
(B) $CuSO_4$ (E) $Ca_3(PO_4)_2$
(C) MgI_2

123. $H_2O + NH_4^+ \leftrightarrow H_3O^+ + NH_3$

Which species are the Bronsted-Lowry bases?

(A) H_2O and H_3O^+ (D) NH_4^+ and NH_3
(B) NH_4^+ and H_3O^+ (E) NH_4^+ and H_2O
(C) H_2O and NH_3

240. $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$

What are the bases in the above reaction?

(A) NH_4^+ and H_2O (D) NH_4^+ and NH_3
(B) NH_3 and H_2O (E) H_2O and OH^-
(C) NH_3 and OH^-

752. The conjugate acid of $H_2PO_4^{2-}$ is

(A) PO_4^{3-} (D) $H_3PO_4^+$
(B) H_3PO_4 (E) None of the above
(C) HPO_4^{2-}

758. Which of the following pairs of substances form a buffer system for human blood?

(A) HCl and Cl^-
(B) NH_3 and NH_2^-
(C) H_2CO_3 and HCO_3^-
(D) $H_3C_6H_5O_7$ and $HC_6H_5O_7^{2-}$
(E) H_3PO_4 and HPO_4^{2-}

870. The conjugate base of $H_2BO_3^-$ is

(A) BO_3^{3-} (D) $H_3BO_3^-$
(B) H_3BO_3 (E) $H_2BO_4^-$
(C) HBO_3^{2-}

871. Which of the following is the **weakest** acid?

(A) $HClO_3$ (D) $HClO_2$
(B) $HClO_4$ **(E) HClO**
(C) HCl

872. Water acts as a base when it reacts with

(A) CN^- **(D) NH_4^+**
(B) NH_3 (E) SO_4^{2-}
(C) NO_2^-

889. Which of the following is a conjugate acid-base pair?

(A) H_3PO_4 and PO_4^{3-} **(D) $H_2PO_4^-$ and HPO_4^{2-}**
(B) $H_2PO_4^-$ and PO_4^{3-} (E) H_3PO_4 and HPO_4^-
(C) H_3PO_4 and HPO_4^{2-}

890. Water will act as a Bronsted-Lowry acid with

(A) ammonia (D) nitric acid
(B) hydrosulfuric acid (E) hydrochloric acid
(C) hydrocyanic acid

899. Sulfur dioxide forms an acidic solution. Which of the following equations could represent this reaction?

(A) $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$
(B) $SO_2(g) + 2\ H_2O(l) \rightarrow H_2SO_4(aq) + H_2(g)$
(C) $SO_2(g) + H_2O(l) \rightarrow SO_3^{2-}(aq) + 2H^+(aq)$
(D) $SO_2(g) + H_2O(l) \rightarrow HSO_2^+(aq) + OH^-(aq)$
(E) $SO_2(g) + H_2O(l) \rightarrow 2\ H^+(aq) + HSO_2^+(aq)$

917. The conjugate acid of the monohydrogen phosphate ions is

(A) PO_4^{3-} (D) $H_2PO_4^{3-}$
(B) $H_2PO_4^-$ (E) HPO_4^{2-}
(C) $H_2PO_4^{2-}$

941. The conjugate acid of H_2O is

(A) O^{2-} (D) H_2O_2
(B) OH^- (E) O^-
(C) H_3O^+

1104. Which of the following properties are common to both strong acids and bases?

I. Taste bitter.
II. Conduct an electric current.
III. Cause neutral litmus to change color.

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

1334. A molecule or ion is classified as a Lewis base if it
(A) receives an electron pair to form a bond
(B) has resonance structures
(C) donates an electron pair to form a bond
(D) donates an electron to a water molecule
(E) receives an electron from a water molecule

1567. Which can never be a base?
(A) SO_3^{2-}
(B) H_2O
(C) HSO_3^-
(D) $H_2PO_4^-$
(E) NH_4^+

1571.

Acid				Base	K_a
H_2SO_4	↔	H^+	+	HSO_4^-	Very Large
HSO_4^-	↔	H^+	+	SO_4^{2-}	1.2×10^{-2}
$Fe(H_2O)_6^{3+}$	↔	H^+	+	$Fe(H_2O)_5(OH)^{2+}$	8.9×10^{-4}
H_2CO_3	↔	H^+	+	HCO_3^-	4.3×10^{-7}
NH_4^+	↔	H^+	+	NH_3	5.7×10^{-10}
HCO_3^-	↔	H^+	+	CO_3^{2-}	5.6×10^{-11}

A water solution of ions is prepared. Based on the Ka values above, which ions will react with the water to produce an acid solution at room temperature?

I. Na^+
II. Fe^{3+}
III. NH_4^+
IV. HCO_3^-
V. HSO_4^-

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

1830. Which shows a progression to a stronger acid as a result of oxidation?
(A) $H_2SO_3 \rightarrow H_2S$
(B) $HClO_4 \rightarrow HCl$
(C) $H_2SO_3 \rightarrow H_2SO_4$
(D) $HCO_3^- \rightarrow H_2CO_3$
(E) $H_2PO_4^- \rightarrow H_3PO_4$

1831. When hydrogen carbonate ion, HCO_3^-, is added to water, the resulting solution is
(A) basic because the solute K_b is greater than K_a
(B) basic because the solute K_a is greater than K_b
(C) acidic because the solute K_a is greater than K_b
(D) acidic because the solute K_b is greater than K_a
(E) neutral because the solute K_b is equal to K_a

1572. A water solution of ions is prepared. Based on the table above, which ions will react with the water to produce a basic solution at room temperature?

Acid				Base	K_a
HCl	↔	H^+	+	Cl^-	Very Large
HNO_3	↔	H^+	+	NO_3^-	Very Large
HF	↔	H^+	+	F^-	3.5×10^{-4}
CH_3COOH	↔	H^+	+	CH_3COO^-	1.8×10^{-5}
HCO_3^-	↔	H^+	+	CO_3^{2-}	5.6×10^{-11}

I. F^-
II. Cl^-
III. NO_3^-
IV. CO_3^{2-}
V. CH_3COO^-

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

1573.

Acid				Base	K_a
HI	↔	H^+	+	I^-	Very Large
HNO_3	↔	H^+	+	NO_3^-	Very Large
HNO_2	↔	H^+	+	NO_2^-	4.6×10^{-4}
NH_4^+	↔	H^+	+	NH_3	5.7×10^{-10}

A water solution of ions is prepared. Based on the Ka values above, which ions will produce a neutral solution at room temperature?

I. I^-
II. K^+
III. NH_3
IV. NO_2^-
V. NO_3^-

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

1833. Adding a few drops of aqueous HCl to a solution containing bromothymol blue indicator will

$HBb(aq) + H_2O(\ell) \leftrightarrow H_3O^+(aq) + Bb^-(aq)$
Yellow **Blue**

(A) make it more basic
(B) make it more blue
(C) make it more yellow
(D) the system remains the same

27. Which of the following is NOT a redox reaction?
(A) $Fe\ (s) + O_2\ (g) \rightarrow Fe_2O_3\ (s)$
(B) $Al^{3+}\ (aq) + PO_4^{3-}\ (aq) \rightarrow AlPO_4\ (s)$
(C) $Zn\ (s) + H^+\ (aq) \rightarrow Zn^{2+}\ (aq) + H_2\ (g)$
(D) $CH_4\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$
(E) $Fe^{3+}\ (aq) + Cu^+\ (aq) \rightarrow Fe^{2+}\ (aq) + Cu^{2+}\ (aq)$

230. $3\ ClO^- + 4\ MnO_4^- + 4\ H^+ \rightarrow 3\ ClO_3^- + 4\ MnO_2 + 2\ H_2O$

In the above reaction, what is the reducing agent?
(A) ClO^-
(B) MnO_4^-
(C) H^+
(D) ClO_3^-
(E) MnO_2

231. $3\ ClO^- + 4\ MnO_4^- + 2\ H_2O \rightarrow 3\ ClO_3^- + 4\ MnO_2 + 4\ OH^-$

In the reaction above, which species is reduced?
(A) ClO^-
(B) MnO_4^-
(C) H_2O
(D) ClO_3^-
(E) MnO_2

241. Step 1. $Cr^{3+} + V^{3+} \rightarrow Cr^{2+} + V^{4+}$
Step 2. $Cr^{3+} + V^{4+} \rightarrow Cr^{2+} + V^{5+}$
Step 3. $Pb^{2+} + V^{5+} \rightarrow Pb^{4+} + V^{3+}$

The above is a proposed mechanism for a catalyzed reaction. The overall products are
(A) Cr^{3+} and Pb^{2+}
(B) Cr^{2+} and Pb^{4+}
(C) Cr^{3+} and Cr^{2+}
(D) Cr^{2+} and V^{3+}
(E) Pb^{4+} and V^{3+}

367. $HS_2O_4^- + MnO_4^- + H_2O \rightarrow SO_4^{2-} + Mn(OH)_4^- + H^+$

What is the reducing agent in the reaction represented above?
(A) $HS_2O_4^-$
(B) MnO_4^-
(C) H_2O
(D) SO_4^{2-}
(E) $Mn(OH)_4^-$

370. Which can be reduced by strong reducing agents, and oxidized by strong oxidizing agents?
(A) CO_3^{2-}
(B) SO_4^{2-}
(C) $C_2O_4^{2-}$
(D) Cl^-
(E) H^+

371. Which can be reduced by strong reducing agents, and oxidized by strong oxidizing agents?
(A) MnO_4^{2-}
(B) F_2
(C) CrO_2^-
(D) ClO_4^-
(E) I^-

732. $2MnO_4^- + 5H_2SO_3 \rightarrow 2Mn^{2+} + 3H_2O + 5SO_4^{2-} + 4H^+$

In the above reaction, the species that undergoes reduction is
(A) S in H_2SO_3
(B) O in MnO_4^-
(C) H in H_2SO_3
(D) O in H_2SO_3
(E) Mn in MnO_4^-

761. $Sb_2O_3 + 6H^+ + 6e^- \rightarrow 2Sb + 3H_2O$

How does the oxidation number of antimony change in the above half reaction?
(A) Increases by 3
(B) Increases by 6
(C) Decreases by 3
(D) Decreases by 6
(E) Decreases by 1.5

789. $O_3 + H_2O + SO_2 \rightarrow SO_4^{2-} + O_2 + 2H^+$

In the redox reaction above, which chemical species is oxidized?
(A) H^+
(B) SO_4^{2-}
(E) SO_2
(C) O_3
(D) O_2

790. A product of the oxidation of NO_2 is
(A) NO
(B) N_2O
(C) NO_2^-
(D) NO_3^-
(E) HNO_3

809. Which of the following species will react with Cl_2 but not with Br_2?
(A) Mn
(B) Acidified Mn^{2+}
(C) Acidified MnO_2
(D) Acidified MnO_4^-
(E) Acidified MnO_4^{2-}

878. Consider the following redox reaction:
$2\ Cr^{3+}(aq) + 3\ Cl_2(aq) + 7\ H_2O(l) \rightarrow$
$Cr_2O_7^{2-}(aq) + 6Cl^-(aq) + 14\ H^+(aq)$

The species which loses electrons is
(A) Cl_2
(B) Cr^{3+}
(C) H_2O
(D) $Cr_2O_7^{2-}$
(E) Cl^-

879. The oxidation number of carbon in CaC_2O_4 is
(A) +7
(B) +2
(C) +3
(D) +4
(E) +6

30. A gaseous mixture containing HF gas (molar mass 20. g) is found to be 90% fluorine (by mass). Assuming none of the other gases contain fluorine, what percent of the mixture is HF?
(A) 100% **(D) 50%**
(B) 95% (E) 10%
(C) 90%

31. A piece of glass (SiO_2) weighs 125 grams and is 4% impure. How many moles of silicon dioxide does it contain?
(A) 1.00 mol **(D) 2.00 mol**
(B) 1.92 mol (E) 2.08 mol
(C) 1.96 mol

Base your answers to questions **32** through **34** on on the following chemical reaction:

$$Zn\ (s) + 2\ HCl\ (aq) \rightarrow ZnCl_2\ (s) + H_2(g)$$

32. How many grams of Zinc (atomic mass 65.0 g) are required to react completely with 1.00 mol HCl?
(A) 32.5 g (D) 195. g
(B) 65.0 g (E) 97.5 g
(C) 130. g

33. How many moles of reactants must be used to produce 33.6 L of hydrogen gas at STP?
(A) 1.50 (D) 4.50
(B) 2.00 (E) 6.00
(C) 3.00

34. If 5.00 moles of zinc is placed into 1.50 L of a 3.00 *M* HCl solution, what is the mass of the hydrogen gas produced?
(A) 0.750 g (D) 5.00 g
(B) 2.25 g (E) 10.0 g
(C) 4.50 g

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35. Base your answer to the following question on the reaction below:

$$UF_6\ (s) + 2\ H_2O\ (l) \rightarrow UF_2O_2\ (s) + 4\ HF\ (g)$$

When a sample of uranium hexaflouride (molar mass 352 g) reacts with an excess of water, 22.4 L of HF are produced at STP. What was the mass of this sample?
(A) 44.0 g (D) 264. g
(B) 88.0 g (E) 352. g
(C) 176. g

136. How many moles of H_2 are needed to produce 15.0 g of C_2H_6 (molecular weight 30.0 g) from C?
(A) 1.50 mol (D) 1.00 mol
(B) 0.750 mol (E) 0.375 mol
(C) 3.00 mol

137. $N_2 + O_2 \rightarrow N_2O_5$

How many moles of O_2 are needed to make 216 g of N_2O_5 in the unbalanced reaction above?
(A) 4.00 **(D) 5.00**
(B) 2.50 (E) 10.0
(C) 20.0

138. How many grams of F_2 are needed to make 113 grams of XeF_5 from Xe? (Molecular mass XeF_5 = 216 g)
(A) 1.25 **(D) 49.7**
(B) 2.00 (E) 52.4
(C) 34.6

139. Alkenes have the general formula C_nH_{2n}. How much of any alkene must be burned in excess oxygen to produce 1.0 mol of H_2O? (Molecular weight of N_2 = 28 g)
(A) 7.0 g (D) 28. g
(B) 14. g (E) 10. g
(C) 18. g

175. A sample of 69.0 grams of lead (atomic mass 207.0 g) is dropped into excess sulfuric acid, what is the volume of hydrogen gas produced?
(A) 22.4 liters (D) 5.60 liters
(B) 11.2 liters (E) 3.74 liters
(C) 7.46 liters

234. What mass of hydrogen has to react with 1.5 mol N_2 to produce NH_3
(A) 1.0 g **(D) 4.5 g**
(B) 1.5 g (E) 6.0 g
(C) 3.0 g

262. Mass of empty container 7.00 g
Mass of container with sample 19.0 g
Volume of sample 6.00 cm^3

The data above was collected to determine the density of an unknown sample. What should the density be reported as?
(A) 3.2 g/cm^3 **(D) 2.00 g/cm^3**
(B) 3.17 g/cm^3 (E) 1.2 g/cm^3
(C) 2.0 g/cm^3

1006. $2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3^-(g)$ $\Delta H = -198$ kJ

There will be NO shift in the above equilibrium when
(A) more O_2 is added
(B) a catalyst is added
(C) the volume is increased
(D) the temperature is increased
(E) the pressure is increased

1086. $CH_3COOH + H_2O \leftrightarrow CH_3COO^- + H_3O^+$

A buffer solution is prepared by adding $NaCH_3COO(s)$ to $CH_3COOH(aq)$. When a few drops of NaOH solution are added to the buffer, the above equilibrium
(A) shifts left and $[CH_3COO^-]$ increases
(B) shifts left and $[CH_3COO^-]$ decreases
(C) shifts right and $[CH_3COO^-]$ increases
(D) shifts right and $[CH_3COO^-]$ decreases
(E) shifts right and $[CH_3COO^-]$ remains the same

1339. the reaction below, where equilibrium has been established

$$N_2\ (g) + 3\ H_2\ (g) \leftrightarrow 2\ NH_3\ (g) + \text{heat}$$

If N_2 is added to this closed system, which of the following will have a lower value than at the original equilibrium?
(A) The amount of nitrogen gas in the system
(B) The amount of hydrogen gas in the system
(C) The amount of ammonia gas in the system
(D) The total pressure of the closed system
(E) The temperature of the closed system

1473. $2\ NO(g) + O_2(g) \leftrightarrow N_2O_4(g)$

What will be the effect of halving the $N_2O_4(g)$ concentration?
(A) $[NO(g)]$ will decrease more than $[O_2(g)]$
(B) $[NO(g)]$ will increase more than $[O_2(g)]$
(C) $[NO(g)]$ will decrease at the same rate as $[O_2(g)]$
(D) $[NO(g)]$ will increase at the same rate as $[O_2(g)]$
(E) $[NO(g)]$ and $[O_2(g)]$ will remain the same

1474. $PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g)$

What will be the effect of doubling the $PCl_3(g)$ concentration?
(A) $[Cl_2(g)]$ will decrease
(B) $[PCl_5(g)]$ will decrease
(C) K_{eq} will decrease
(D) K_{eq} will increase
(E) Equilibrium will never be established under these new conditions

1601. $AgCl(s) + 2\ NH_3(aq) \leftrightarrow Ag(NH_3)_2^+(aq) + Cl^-(aq)$

If more ammonia, NH_3, is added to the above system at equilibrium, the
(A) amount of $AgCl(s)$ increases.
(B) system cannot achieve equilibrium.
(C) rate of the forward reaction decreases.
(D) concentration of $Ag(NH_3)_2^+(aq)$ increases.
(E) the entropy of the system decreases

1603. $AgCl(s) + 2\ NH_3(aq) \leftrightarrow Ag(NH_3)_2^+(aq) + Cl^-(aq)$

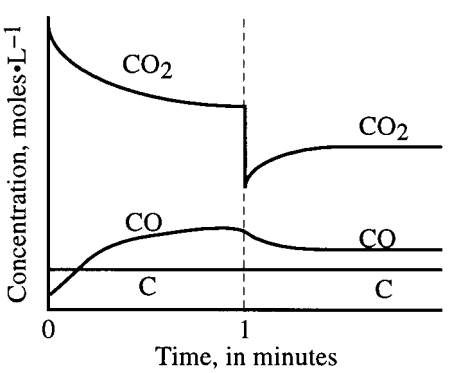
An increase in the concentration of $Cl^-(aq)$ in the above reaction causes
(A) the $[NH_3(aq)]$ to decrease
(B) $Ag(NH_3)_2^+$ to form
(C) $AgCl(s)$ to dissociate
(D) $[AgCl(s)] = [NH_3(aq)]$
(E) $AgCl(s)$ to precipitate

1605. $AgCl(s) + 2\ S_2O_3^{2-}(aq) \leftrightarrow Ag(S_2O_3)_2^{3-}(aq) + Cl^-(aq)$

If more $S_2O_3^{2-}$ is added to the above system at equilibrium, the
(A) amount of $AgCl(s)$ increases
(B) rate of forward reaction decreases
(C) concentration of $Cl^-(aq)$ increases
(D) concentration of $Ag(S_2O_3)_2^{3-}(aq)$ decreases
(E) equilibrium cannot be reestablished

1606. At the time, 1 minute, which change was made to this reaction?

$$C(s) + CO_2(g) \leftrightarrow 2\ CO(g) + \text{Heat}$$



(A) The pressure was increased
(B) Carbon monoxide was added
(C) The volume of the system was decreased
(D) The temperature was decreased
(E) Carbon dioxide was removed

937. $PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g)$

When 0.40 mol of PCl_3 and 0.40 mol of Cl_2 are placed in a container and allowed to reach equilibrium according to the above reaction, 0.244 mol of PCl_5 are present. From this information, what should K_{eq} be?

(A) 0.10
(B) 0.30
(C) 33
(D) 3.3
(E) 10

982. For an exothermic reaction at equilibrium, an increase in temperature will cause the equilibrium to shift

(A) left and K_{eq} increases
(B) left and K_{eq} decreases
(C) right and K_{eq} increases
(D) right and K_{eq} decreases
(E) right and K_{eq} remains the same

983. $PCl_5(g) \leftrightarrow PCl_3(g) + Cl_2(g)$

At equilibrium, $[PCl_5]$ is 0.400 *M*, $[PCl_3]$ is 1.50 *M* and $[Cl_2]$ is 0.600 *M*. The K_{eq} for the reaction above is

(A) 0.360
(B) 0.444
(C) 0.900
(D) 2.25
(E) 2.50

987. $OCl^-(aq) + HC_7H_5O_2(aq) \leftrightarrow HOCl(aq) + C_7H_5O_2^-(aq)$
$K_{eq} = 2.1 \times 10^3$

When the above system is at equilibrium

(A) products are favored and HOCl is the stronger acid
(B) reactants are favored and HOCl is the stronger acid
(C) products are favored and $HC_7H_5O_2$ is the stronger acid
(D) reactants are favored and $HC_7H_5O_2$ is the stronger acid
(E) products are favored and $C_7H_5O_2^-$ is the stronger acid

1005. $2\ NH_3(g) \leftrightarrow N_2(g) + 3\ H_2(g)$

A flask is initially filled with NH_3. As the system approaches equilibrium, the rate of the forward reaction

(A) increases as the rate of the reverse reaction decreases
(B) decreases as the rate of the reverse reaction increases
(C) increases as the rate of the reverse reaction increases
(D) decreases as the rate of the reverse reaction decreases
(E) remains constant as the rate of the reverse reaction decreases

1007. $N_2O_4(g) \leftrightarrow 2\ NO_2(g)$ $K_{eq} = 0.133$

When the above reaction is at equilibrium, the $[N_2O_4]$ is equal to

(A) $\dfrac{0.133}{[NO_2]^2}$
(B) $\dfrac{[NO_2]}{0.133}$
(C) $\dfrac{[NO_2]^2}{(0.133)^2}$
(D) $\dfrac{0.133}{[NO_2]}$
(E) $\dfrac{[NO_2]^2}{0.133}$

1009. $C(s) + H_2O(g) \leftrightarrow CO(g) + H_2(g)$

The contents of a 1.00 L container at equilibrium were analyzed and found to contain 0.20 mol C, 0.20 mol H_2O, 0.60 mol CO and 0.60 mol H_2. If the system behaves like the equation above, the equilibrium constant is

(A) 0.11
(B) 0.56
(C) 9.0
(D) 11.2
(E) 1.8

1025. $2\ HBr(g) \leftrightarrow H_2(g) + Br_2(g)$

At high temperature, 0.500 mol HBr was placed in a 1.00 L container where it decomposed to give the above equilibrium.

At equilibrium, the $[Br_2]$ is 0.0855 mol/L. What is the value of the equilibrium constant?

(A) 3.29×10^{-1}
(B) 8.55×10^{-2}
(C) 4.18×10^{-3}
(D) 3.21×10^{-3}
(E) 6.75×10^{-3}

1033. $Br_2(g) \leftrightarrow Br_2(l)$

The equilibrium constant for the above system is

(A) $K_{eq} = \dfrac{[Br_2(l)]}{[Br_2(g)]}$
(B) $K_{eq} = [Br_2(g)]$
(C) $K_{eq} = \dfrac{1}{[Br_2(g)]}$
(D) $K_{eq} = [Br_2(g)][Br_2(l)]$
(E) $K_{eq} = \dfrac{[Br_2(g)]}{[Br_2(l)]}$

841. 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) $NaCl(aq) \rightarrow Na^+(aq) + Cl^-(aq)$

842. Milk is refrigerated in order to slow the rate of decomposition by bacterial action. The decrease in reaction rate is due to
(A) an increase in surface area
(B) a decrease in surface area
(C) a decrease in the fraction of particles possessing sufficient energy
(D) a decrease in ΔH for the reaction
(E) the introduction of an alternate pathway with greater activation energy

909. Which of the following would react most rapidly?
(A) powdered Zn in 1.0 *M* HCl at 25ºC
(B) powdered Zn in 2.0 *M* HCl at 25ºC
(C) a lump of Zn in 2.0 *M* HCl at 25ºC
(D) a lump of Zn in 1.0 *M* HCl at 40ºC
(E) a lump of Zn in 1.0 *M* HCl at 30ºC

Base your answers to questions **1454** and **1455** on the following reaction.

$$H_2(g) + I_2(g) \leftrightarrow 2\ HI(g)$$

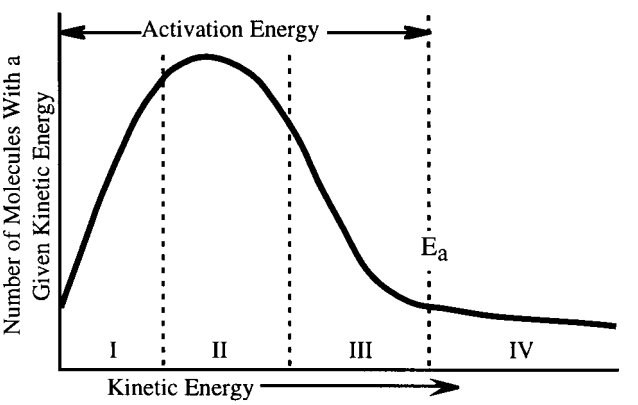
1454. The reaction above is allowed to reach equilibrium. The pressure on the system is doubled. Which of the following is true?
(A) $[H_2]$ will increase.
(B) $[I_2]$ will increase.
(C) [HI] will decrease.
(D) 1 and 2
(E) None of these

1455. NOTE: This question is about the forward reaction ONLY. At constant volume, the temperature of the system is doubled. Which of the following will occur?
(A) The kinetic energy of the molecules will decrease.
(B) Nothing will change.
(C) The reaction rate will more than double.
(D) The reaction rate will double.
(E) The reaction rate will be halved.

1462. The fraction of molecules with the activation energy in a reaction will be (approximately) doubled by which of the following?
(A) halving the velocity of the molecules in reaction
(B) doubling the reaction rate by increasing temperature
(C) halving the number of collisions
(D) doubling the activation energy
(E) doubling the potential energy

1577. 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

1579.



The relative number of molecules with a given kinetic energy is plotted against kinetic energy. An uncatalyzed reaction with an activation energy, E_a, is being considered. In which region of the above kinetic energy distribution graph will all collisions result in a chemical reaction?
(A) area I only
(B) area IV only
(C) areas II and III only
(D) areas I, II and III only
(E) areas I and IV only

1591. A rise in temperature of 10 Kelvins causes the rate of some chemical reactions to double. This is best explained by the doubling of the:
(A) heat of reaction, ΔH
(B) the activation energy
(C) average kinetic energy of molecules
(D) pressure of the system
(E) number of reacting particles with the minimum activation energy

286.

Bond	Energy (kJ/mol)
H-H	436
N-N	945
H-N	314

Based on the above table, what is the enthalpy change for the reaction $3\ H_2 + N_2 \rightarrow 2\ NH_3$?

(A) 369kJ (D) 459kJ
(B) –369kJ (E) –1067kJ
(C) –459kJ

494. $CH_4(g) + 2\ Br_2(l) \rightarrow CH_2Br_2(g) + 2\ HBr(g)$
$\Delta H = -0.5$ kcal

Substance	ΔH_f^o, kcal
$CH_4(g)$	–17.9
HBr(g)	–8.7

Based on the above table and equation, what is the standard heat of formation for $CH_2Br_2(g)$?

(A) –9.7 **(D) –1.0**
(B) 9.7 (E) +1.0
(C) –1.5

495.

Bond	Bond energy, kJ mol^{-1}
C-C in graphite	715
O-O in oxygen	498
C-O in carbon dioxide	?

$C_{graphite} + O_2(g) \rightarrow CO_2(g) \quad \Delta H_f^o = -394$ kJ mol^{-1}

Based on the above table and equation, what is the strength of a C-O bond?

(A) 819 kJ mol^{-1} (D) 1607 kJ mol^{-1}
(B) 409.5 kJ mol^{-1} (E) 606.5 kJ mol^{-1}
(C) 803.5 kJ mol^{-1}

1208. When a solute with an exothermic heat of reaction is dissolved in water, what is most likely to occur?

(A) Covalent bonds will be formed.
(B) Hydrogen gas will be released.
(C) The temperature of the solution will increase as the solute dissolves.
(D) The solution will become acidic.
(E) The solution will begin to boil.

497.

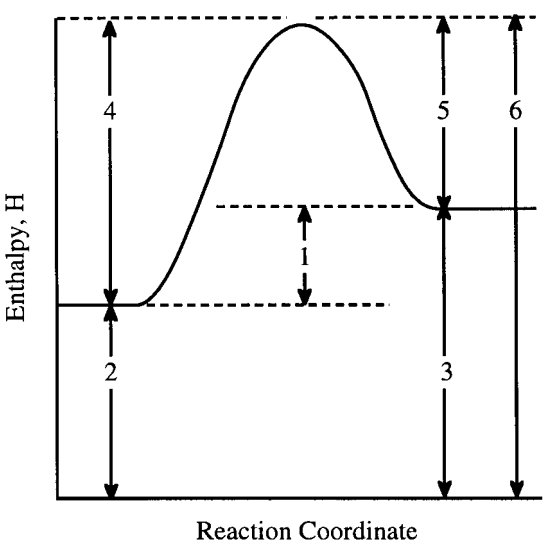
Bond	Bond energy, kJ mol^{-1}
C-C in graphite	715
Cl-Cl in chlorine	243
C-Cl in carbon tetrachloride	?

$C_{graphite} + 2\ Cl_2(g) \rightarrow CCl_4 \quad \Delta H_f^o = -107$ kJ mol^{-1}

Based on the above table and equation, what is the bond energy of the C-Cl bond?

(A) 240 kJ mol^{-1} (D) 273.5 kJ mol^{-1}
(B) 1308 kJ mol^{-1} (E) 266 kJ mol^{-1}
(C) 327 kJ mol^{-1}

1586. Base your answer to the following question on the diagram shown below.



The products have an energy represented by number

(A) 6 (D) 4
(B) 2 (E) 5
(C) 3

1640. $12\ O_2(g) + H_2(g) \rightarrow H_2O(g) + 243$ kJ
$12\ O_2(g) + 2\ H(g) \rightarrow H_2O(g) + 661$ kJ

Given the above two equations, how much energy is needed to dissociate 1.00 mole of H_2 according to the equation below?

$H_2(g) \rightarrow 2H(g)$

(A) 243 kJ (D) 904. kJ
(B) 418 kJ (E) 1320 kJ
(C) 661. kJ

180. A 1.25g sample of MgC_2O_4, containing an inert impurity, was dissolved in enough water to make 250. mL of solution. The solution was then titrated with $NaMnO_4$. The balanced equation for the titration was

$$16\ H^+(aq) + 2\ MnO_4^-(aq) + 5\ C_2O_4^{2-}(aq) \rightarrow 2\ Mn^{2+}(aq) + 10\ CO_2(g) + 8\ H_2O(l)$$

The volume of the 0.0200M $NaMnO_4$ needed to reach the equivalence point was 184. mL.

(a) Identify the reducing agent in the reaction
(b) For the titration at the equivalence point, find the number of moles of MnO_4^- and $C_2O_4^{2-}$ that reacted.
(c) Calculate the mass percent of MgC_2O_4 (*s*) in the impure sample.
(a) $C_2O_4^{2-}$
(b) 0.00368 mol and 0.00920 mol
(c) 82.4%

192. Consider the reaction, $CO(g) + O_3(g) \rightarrow CO_2(g) + O_2(g)$, and the table below.

	CO_2	$CO(g)$	$O_3(g)$
Standard enthalpy of formation (ΔH_f°) at 25°C	–26	–94	34

(a) What is the enthalpy change for this reaction at 25ºC?
(b) Predict the magnitude and sign of the entropy change and justify your answer
(c) based on your answers to parts (a) and (b) is this reaction spontaneous? Why or why not?
(a) –102 kcal
(b) The entropy change would be negligible since both the number and complexity of gaseous molecules does not significantly change.
(c) Since the enthalpy change is negative and the entropy change is negligible, the free energy change is negative and therefore the reaction is spontaneous ($\Delta G = \Delta H - T\Delta S$)

193. Consider the following reaction and table.

$$2\ NO(g) + \tfrac{1}{2}\ O_2(g) \rightarrow N_2O_3(g)$$

Trial	*Initial [NO]* ($mol\ L^{-1}$)	*Initial [O_2]* ($mol\ L^{-1}$)	*Initial rate of Formation of N_2O_3* ($mol\ L^{-1}\ min^{-1}$)
1	x	y	1.0×10^{-6}
2	2x	y	4.0×10^{-6}
3	x	2y	2.0×10^{-6}
4	2x	4y	1.6×10^{-5}

(a) What is the rate law for this reaction
(b) Consider the following reaction mechanism for this reaction. Which is the slowest step? Justify your answer.

Step 1: $NO + NO \rightarrow N_2O_2$
Step 2: $N_2O_2 + O_2 \rightarrow N_2O_3 + O$
Step 3: $O + O \rightarrow \tfrac{1}{2}\ O_2$
(a) rate = $k[NO]^2[O_2]$
(b) Step 2 is the rate determining step since it is the only choice that would lead to ther rate law given in part (a). ***(Note: if part (a) is wrong, yet answer in part (b) is consistant with answer in part (a), credit is still given)***

453. A piece of zinc and a piece of tin are placed in separate beakers containing $Fe(NO_3)_2$.
(a) What reactions occur in each beaker?
(b) Account for any differences between the reactions in terms of physical or chemical properties of the reactants.
(a) The zinc would dissolve, causing the solution to fizz and turn colorless. The tin would not react.
(b) Zinc is a better reducing agent than iron (II); tin is not.

67. 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

The solution of which is a major component of acid rain?

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

Base your answers to questions **71** through **74** on the chemicals below.

(A) Carbon dioxide
(B) Hydrofluoric acid
(C) Magnesium sulfate
(D) Potassium chromate
(E) Calcium carbonate

71. Which is used commercially to melt ice?

(A) A (D) D
(B) B **(E) E**
(C) C

74. Which is used commercially to etch glass?

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

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85. Base your answer to the following question on the ions below.

(A) NH_4^+
(B) Pb^{2+}
(C) CrO_4^{2-}
(D) CO_3^{2-}
(E) F^-

There is an odor when slowly added to a solution of sodium hydroxide

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

Base your answers to questions **216** through **219** on the elements below.

(A) Pb
(B) Cd
(C) U
(D) Ga
(E) Ni

216. Which is typically used as shielding from radiation?

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

217. Which is used to dope silicon for use in transistors?

(A) A **(D) D**
(B) B (E) E
(C) C

218. Which is used as a source of fissionable material?

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

219. Which is used as control rods in nuclear reactors?

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

1184. 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 a high affinity toward hemoglobin?

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

1342. Base your answer to the following question on the reaction below, where equilibrium has been established

$$N_2\,(g) + 3\,H_2\,(g) \leftrightarrow 2\,NH_3\,(g) + \text{heat}$$

The above reaction is known as the

(A) Bessamer process (D) Arc process
(B) Hall process **(E) Haber process**
(C) Héroult process

163. A chemical reaction results in the production of a gas, which is collected by displacing water in a flask inverted in a trough of water. Which piece of information is NOT needed to determine the molecular mass of this gas?
(A) Atmospheric pressure
(B) Temperature of the gas
(C) Volume of displaced water
(D) Mass of the gas
(E) Number of atoms in 1 molecule of the gas

1220. Which of the following are proper laboratory procedures?

I. Wait until hot objects have reached room temperature before finding their mass.
II. Always rinse a buret with water before adding a titrant.
III. When mixing solutions, always add water to the acid.

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

1233. A student calculated the mass of a small piece of unreactive metal. This piece of metal was added to a partially filled graduated cylinder. The following measurements were made by the student:
Mass of metal = 13.689 grams
Volume of water before the metal was added= 7.51 milliliters
Volume of water after the metal was added= 9.41 milliliters
The density of the metal should be reported as
(A) 7.2047 g/mL
(B) 7.205 g/mL
(D) 7.2 g/mL
(E) 7 g/mL
(C) 7.20 g/mL

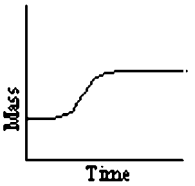
1311. To treat an acid splash on skin, the best emergency procedure is to flush the skin with water and what other substance?
(A) NaOH
(B) Na_2SO_4
(D) NaH_2PO_4
(E) NaCl
(C) $NaHCO_3$

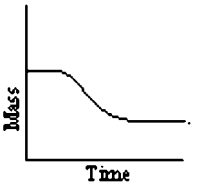
1421. Which number contains exactly 5 significant digits?
(A) 5.02×10^{-5}
(B) 34100
(C) 0.00003
(D) 0.0782×10^{-3}
(E) 32312×10^{52}

1817. Collection of a gas by the displacement of water is only possible if the gas is
(A) lighter than air.
(B) heavier than air.
(C) water soluble.
(D) water insoluble.
(E) a halogen or noble gas

1539. A narrow-necked, stoppered bottle contains concentrated sulfuric acid. When the acid is being poured into a beaker, the stopper should be
(A) rinsed with distilled water.
(B) placed into the reaction beaker.
(C) placed out of the way on the lab table.
(D) held inverted between the middle fingers.
(E) rinsed with sulfuric acid.

1540. Iron is heated in a reaction vessel into which oxygen gas is fed. All of the iron is converted to iron (III) oxide (rust), Fe_2O_3. The mass of the reaction vessel does not change during the reaction. Which graph shows the change in the combined mass of the reaction vesssel and its contents?

(A)


(C)


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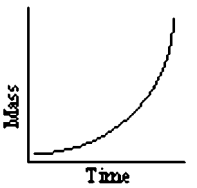
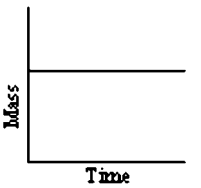


(D)


1822. Which constituent of a sample of brass containing zinc, copper, tin, and lead can be determined using a spectrophotometer?
(A) Zinc
(B) Copper
(C) Tin
(D) Lead
(E) None of these elements can be determined using a spectrophotometer

1967. Two substances, A and B were separated after being in solution by distillation. Distillation works because A and B have different
(A) crystal colors
(B) solubilities
(C) densities
(D) boiling points
(E) melting points