AP CHEMISTRY EXAM

Q1

Which of the following usually exists as a monatomic anion in most of its compounds?

(A) Fe

(B) Ne

(C) F

(D) Na

Q2

What is the name of the energy change when a gaseous atom, in the ground state, adds an electron?

(A) ionization energy

(B) sublimation energy

(C) atomization energy

(D) electron affinity

Q3

If the name of a binary compound, a compound containing only two elements, contains a multiplying prefix, such as di- or tri-, then the compound is most likely:

(A) ionic
(B) molecular
(C) metallic
(D) unstable

Q4

Bromine forms a series of acids like the series formed by chlorine. Which of the following series of bromine acids list the acids in order of increasing amount of oxygen present?
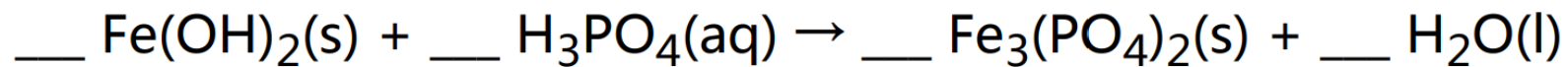
(A)   bromous acid, hypobromous acid, perbromic acid, bromic acid
(B)   bromous acid, bromic acid, hypobromous acid, perbromic acid
(C)   perbromic acid, bromic acid, bromous acid, hypobromous acid
(D)   hypobromous acid, bromous acid, bromic acid, perbromic acid

Q5

A—Based on their positions on the periodic table:

C	+4 to −4
F	−1 and 0 (element)
O	−2 to 0
Ca	+2 and 0

Q6

___ $Fe(OH)_2$(s) + ___ H_3PO_4(aq) → ___ $Fe_3(PO_4)_2$(s) + ___ H_2O(l)

After the above chemical equation is balanced, the lowest whole-number coefficient for water is:

(A) 3
(B) 1
(C) 9
(D) 6

Q7

A sample is tested for the presence of the Hg^{2+} ion. This ion, along with others, may be precipitated with chloride ion. If Hg^{2+} is present in the chloride precipitate, a black color will form upon treatment with aqueous ammonia. The balanced net ionic equation for the formation of this black color is:

(A) $Hg_2Cl_2 + 2 NH_3 + 2 H_2O \rightarrow 2 Hg + 2 NH_4^+ + 2 Cl^- + 2 OH^-$

(B) $Hg_2Cl_2 + 2 NH_3 \rightarrow Hg + HgNH_2Cl + NH_4^+ + Cl^-$

(C) $Hg_2Cl_2 + 2 NH_4^+ \rightarrow 2 Hg + 2 NH_4Cl$

(D) $Hg_2Cl_2 + NH_4^+ \rightarrow 2 Hg + NH_4Cl + Cl^-$

Q8

A solution is prepared for qualitative analysis. The solution contains the following ions: Co^{2+}, Pb^{2+}, and Al^{3+}. Which of the following will cause no observable reaction?

(A) Dilute $NH_3(aq)$ is added.

(B) Dilute $K_2CrO_4(aq)$ is added.

(C) Dilute $HNO_3(aq)$ is added.

(D) Dilute $K_2S(aq)$ is added.

How many milliliters of 0.100 M H_2SO_4 are required to neutralize 50.0 mL of 0.200 M KOH?
(A) 25.0 mL
(B) 30.0 mL
(C) 20.0 mL
(D) 50.0 mL

$3 \ Cu(s) + 8 \ HNO_3(aq) \rightarrow 3 \ Cu(NO_3)_2(aq) + 2 \ NO(g) + 4 \ H_2O(l)$

Copper metal reacts with nitric acid according to the above equation. A 0.30 mole sample of copper metal and 10.0 mL of 12 M nitric acid are mixed in a flask. How many moles of NO gas will form?

(A) 0.060 mole

(B) 0.030 mole

(C) 0.010 mole

(D) 0.20 mole

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(A) 0.060 mole

(B) 0.030 mole

(C) 0.010 mole

(D) 0.20 mole

Q12

When the following equation is balanced, it is found that 1.00 mole of C_8H_{18} reacts with how many moles of O_2?

__ $C_8H_{18}(g)$ + __ $O_2(g)$ → __ $CO_2(g)$ + __ $H_2O(g)$
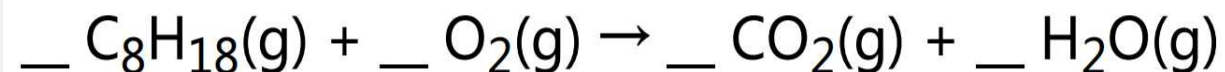
(A) 12.5 moles
(B) 10.0 moles
(C) 25.0 moles
(D) 37.5 moles

A student has three identical 2.0 L flasks (A, B, and C) all at 298 K. Each flask has an 8.0 g sample of gas sealed inside. Flask A contains methane, CH_4; flask B contains hydrogen, H_2; and flask C contains helium, He. Rank the three flasks in order of decreasing pressure.

(A)   A > B > C

(B)   B > C > A

(C)   C > A > B

(D)   All three flasks are at the same pressure.

Q14

Increasing the temperature of an ideal gas from 50°C to 75°C at constant volume will cause which of the following to increase for the gas?

(A)   the average molecular mass of the gas

(B)   the average distance between the molecules

(C)   the average speed of the molecules

(D)   the density of the gas

Q15

Each of four 5.0 L containers is filled with a different gas (He, CH_4, O_2, and CO_2). Each container contains 0.75 mole of gas at 273 K. If one of the containers springs a small leak, which of the following will change in that container?

(A)   moles, temperature, and pressure
(B)   moles and pressure
(C)   temperature and pressure
(D)   moles and temperature

Q16

Each of four 5.0 L containers is filled with a different gas (He, CH_4, O_2, and CO_2). Each container contains 0.75 mole of gas at 273 K. If one of the containers springs a small leak, which of the following will change in that container?
(A)   moles, temperature, and pressure
(B)   moles and pressure
(C)   temperature and pressure
(D)   moles and temperature

Q17

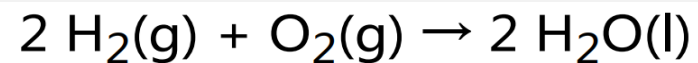Which of the following is the minimum energy required to initiate a reaction?
(A)   free energy
(B)   lattice energy
(C)   kinetic energy
(D)   activation energy

Magnesium metal reacts readily with liquid bromine under standard conditions. Which of the following conclusions may be drawn from this fact?

(A) $K_{eq} < 1$ and $\Delta G° > 0$

(B) $K_{eq} > 1$ and $\Delta G° = 0$

(C) $K_{eq} < 1$ and $\Delta G° < 0$

(D) $K_{eq} > 1$ and $\Delta G° < 0$

$2 H_2(g) + O_2(g) \rightarrow 2 H_2O(l)$

From the table below, determine the enthalpy change for the above reaction.

BOND	AVERAGE BOND ENERGY (kJ/mol)
H–H	436
O=O	499
H–O	464

(A) 0 kJ
(B) 485 kJ
(C) –485 kJ
(D) 464 kJ

Q20

If you have a table of standard thermodynamic values for the substances involved in the reaction, how might the temperature at which the reaction changes from spontaneous to nonspontaneous be predicted?

(A) It is impossible to predict the temperature.

(B) The change will occur at 298 K (25°C).

(C) ΔG cannot change from spontaneous to nonspontaneous.

(D) At this point, $\Delta G = 0$, which leads to $T = \Delta H/\Delta S$.

Q21

Which of the following represents the electron arrangement for the least reactive element?

(A) 1s ↑ 2s ↑↓

(B) 1s↑↓ 2s ↑

(C) [Kr] 5s ↑↓ 4d ↑↑ __

(D) 1s ↑↓ 2s ↑↓ 2p ↑↓↑↓↑↓
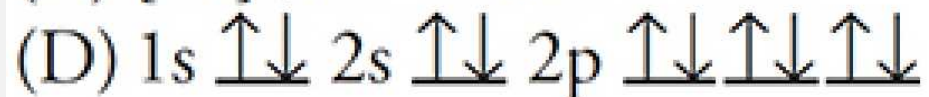
Q22

The ground-state configuration of Fe^{2+} is which of the following?

(A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

(B) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

(C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

(D) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

Q23

The following are some electron configurations reported by four students. Which of the following electron configurations is not possible?

(A) $1s^2 2s^3 2p^3$

(B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$

(C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$

(D) $1s^2 2s^2 2p^5$

Q24

If all the electrons are present in pairs, a substance is said to be diamagnetic. If there is at least one electron by itself in an orbital, a substance is said to be paramagnetic. In which of the following groups are all atoms diamagnetic?

(A)   Be, O, and N

(B)   Mg, Se, and Xe

(C)   Kr, Be, and Zn

(D)   At, Sn, and Ba

Q25

Calcium reacts with element X to form an ionic compound. If the ground-state electron configuration of X is $1s^2 2s^2 2p^4$, what is the simplest formula for this compound?

(A) CaX

(B) CaX_2

(C) Ca_4X_2

(D) Ca_2X_2

Q26

VSEPR predicts an SbF_5 molecule will be which of the following shapes?

(A) tetrahedral

(B) trigonal bipyramidal

(C) square pyramid

(D) trigonal planar

Q27

Which of the following does not have one or more p bonds?

(A) H_2O

(B) HNO_3

(C) O_2

(D) N_2

Which of the following is nonpolar?

(A) IF_5

(B) IF_3

(C) SiF_4

(D) SeF_4

Which of the following has more than one unshared pair of valence electrons on the central atom?

(A) BrF_5

(B) NF_3

(C) IF_7

(D) ClF_3

Q30

The electron pairs point toward the corners of which geometrical shape for a molecule with sp^2 hybrid orbitals?

(A) trigonal planar
(B) octahedron
(C) trigonal bipyramid
(D) trigonal pyramid

Q31

Which of the following molecules or ions has the greatest number of unshared electrons around the central atom?
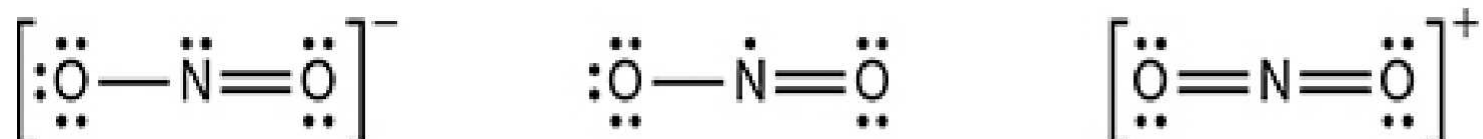
(A) SO_2

(B) NO_3^-

(C) KrF_2

(D) SF_4

Q32

Which of the following sets of bonds is listed in order of increasing covalent character?

(A) Na–Cl < Al–Cl < P–Cl < Cl–Cl

(B) Na–Cl < P–Cl < Cl–Cl < Al–Cl

(C) P–Cl < Cl–Cl < Al–Cl < Na–Cl

(D) Al–Cl < Na–Cl < P–Cl < Cl–Cl

$$\left[:\ddot{O}-\ddot{N}=\ddot{O} \right]^{-} \qquad :\ddot{O}-\dot{N}=\ddot{O} \qquad \left[\ddot{O}=N=\ddot{O} \right]^{+}$$

There are three nitrogen–oxygen species known with a 1:2 nitrogen-to-oxygen ratio. The Lewis electron-dot diagrams for these three nitrogen oxygen species are shown in the above diagram. Which of the three has the largest bond angle?

(A) NO_2^-

(B) NO_2

(C) NO_2^+

(D) All have a 180° angle.

Q34

The best description of the interactions in $KNO_3(s)$ is which of the following?

(A) KNO_3 is composed of macromolecules held together by strong bonds.

(B) KNO_3 is composed of atoms held together by delocalized electrons.

(C) KNO_3 is composed of positive and negative ions held together by electrostatic attractions.

(D) KNO_3 is composed of molecules held together by intermolecular dipole–dipole interactions.

Q35

Most molecular species vaporize as simple molecules. However, acetic acid, CH_3COOH, is an exception. In the gaseous state, acetic acid molecules exist as pairs known as dimers. What is the most probable cause of this behavior?

(A) London dispersion forces

(B) covalent bonding

(C) hydrogen bonding

(D) metallic bonding

Strontium sulfate, $SrSO_4$, will precipitate when a solution of sodium sulfate is added to a strontium nitrate solution. What will be the strontium ion, Sr^{2+}, concentration remaining after 30.0 mL of 0.10 M Na_2SO_4 solution are added to 70.0 mL of 0.20 M $Sr(NO_3)_2$ solution?

(A) 0.14 M
(B) 0.15 M
(C) 0.11 M
(D) 0.20 M

Q37

A solution has 10 g of urea in 100 g of solution. Which of the following are needed to calculate the molarity of this solution?

(A) the density of the solution and the molecular weight of urea

(B) the density of urea and the molecular weight of urea

(C) the density of the solvent and the density of the solute

(D) the molecular weight of urea and the density of the solvent

Q38

Pick the conditions that would yield the highest concentration of $N_2(g)$ in water.

(A) partial pressure of N_2 = 1.0 atm; temperature of water = 25°C

(B) partial pressure of N_2 = 0.50 atm; temperature of water = 55°C

(C) partial pressure of N_2 = 2.0 atm; temperature of water = 25°C

(D) partial pressure of N_2 = 2.0 atm; temperature of water = 85°C

Q39

ION	IONIC RADIUS (PM) (CUBIC ENVIRONMENT)
Na^+	132
Cd^{2+}	124
La^{3+}	130

The energy change in the following reaction is the heat of hydration:

$$M^{n+}(g) + x\,H_2O(l) \rightarrow M(H_2O)_x^{n+}(aq)$$
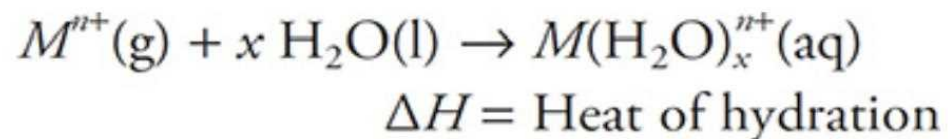
$$\Delta H = \text{Heat of hydration}$$

In general, the heat of hydration is exothermic. Assuming the value of x is the same in all cases, which of the following correctly predicts the relative order of the heats of hydration for the ions listed in the table and gives a correct explanation?

(A) $Na^+ > Cd^{2+} > La^{3+}$ because ions of elements lower on the periodic table have lower hydration energies.

(B) $Cd^{2+} > La^{3+} > Na^+$ because smaller radii lead to higher hydration energies.

(C) $La^{3+} > Cd^{2+} > Na^+$ because higher charges lead to higher hydration energies.

(D) All are about the same because their ionic radii are similar.

Q40

The reaction of bromine, Br_2, with nitrogen oxide, NO, is $Br_2(g) + 2\ NO(g) \rightarrow 2\ NOBr(g)$.

For this reaction, the observed rate law is Rate $= k\ [Br_2]\ [NO]^2$. Why is the following unlikely to be in the mechanism?

$Br_2(g) + 2\ NO(g) \rightarrow 2\ NOBr(g)$
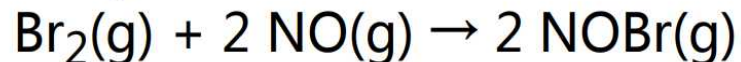
(A) NO is an unstable molecule.

(B) Br_2 is too stable to react.

(C) This is a ternary step.

(D) This could be a step in the mechanism.

Q41

Acid	K_a, acid dissociation constant
H_3PO_4	7.2×10^{-3}
$H_2PO_4^-$	6.3×10^{-8}
HPO_4^{2-}	4.2×10^{-13}

Using the given information, choose the best answer for preparing a buffer with a pH of 8.

(A) $K_2HPO_4 + KH_2PO_4$

(B) H_3PO_4

(C) $K_2HPO_4 + K_3PO_4$

(D) K_3PO_4

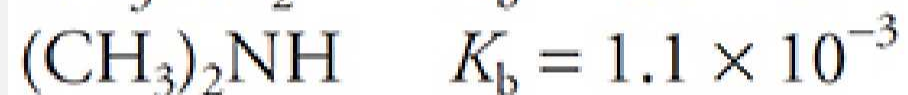$2 CH_4(g) + O_2(g) \rightleftharpoons 2 CO(g) + 4 H_2(g)\ \Delta H < 0$

To increase the value of the equilibrium constant, K, which of the following changes must be made to the above equilibrium?

(A)   increase the temperature

(B)   increase the volume

(C)   decrease the temperature

(D)   add CO(g)

Ionization Constants

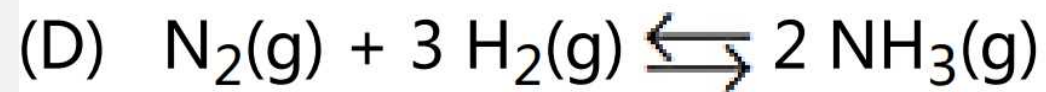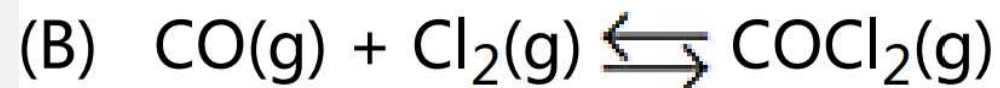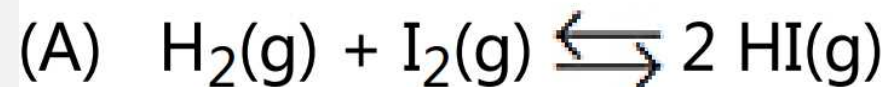NH_3 $\qquad$ $K_b = 1.8 \times 10^{-5}$

CH_3NH_2 $\qquad$ $K_b = 4.4 \times 10^{-4}$

$(CH_3)_2NH$ $\qquad$ $K_b = 1.1 \times 10^{-3}$

How would a solution with an initial NH_4Cl ($NH_4^+ + Cl^-$) concentration of 1 M and an initial CH_3NH_3Cl ($CH_3NH_3^+ + Cl^-$) concentration of 1 *M* be classified?

(A) a solution with a pH > 7, which is a buffer

(B) a solution with a pH < 7, which is not a buffer

(C) a solution with a pH < 7, which is a buffer

(D) a solution with a pH > 7, which is not a buffer

Q44

For which of the following equilibriums will $K_c = K_p$?

(A) $H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$

(B) $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$

(C) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

(D) $N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$

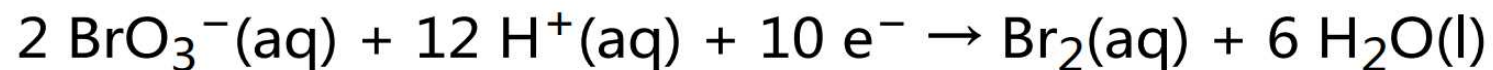**Q45**

How many moles of Pt may be deposited on the cathode when 0.80 F of electricity is passed through a 1.0 M solution of Pt^{4+}?

(A)   1.0 mole

(B)   0.60 mole

(C)   0.20 mole

(D)   0.80 mole

Q46

$2 \, BrO_3^-(aq) + 12 \, H^+(aq) + 10 \, e^- \rightarrow Br_2(aq) + 6 \, H_2O(l)$

Which of the following statements is correct for the above reaction?

(A) The BrO_3^- undergoes oxidation at the anode.

(B) Br goes from a –1 oxidation to a 0-oxidation state.

(C) Br_2 is oxidized at the anode.

(D) The BrO_3^- undergoes reduction at the cathode.

Q47

A chemist constructs a galvanic cell with a tin, Sn, electrode in a compartment containing a 1.0 M tin(II) perchlorate, $Sn(ClO_4)_2$, solution and a platinum, Pt, electrode in a compartment containing a 1.0 M copper(II) chloride, $CuCl_2$, solution. The salt bridge connecting the two compartments contains a 1.0 M potassium sulfate, K_2SO_4. Which of the following is the net ionic equation for the cell?

(A) $CuCl_2(aq) + Sn(s) \rightarrow SnSO_4(aq) + Cu(s)$

(B) $Sn^{2+}(aq) + Cu(s) \rightarrow Cu^{2+}(aq) + Sn(s)$

(C) $Cu^{2+}(aq) + Sn(s) \rightarrow Sn^{2+}(aq) + Cu(s)$

(D) $2\,Cl^-(aq) + 2\,H_2O(l) \rightarrow H_2(g) + 2\,OH^-(aq) + Cl_2(g)$

Q48

Which of the following will have the smallest mass defect?

(A) ^{238}U

(B) ^{12}C

(C) ^{56}Fe
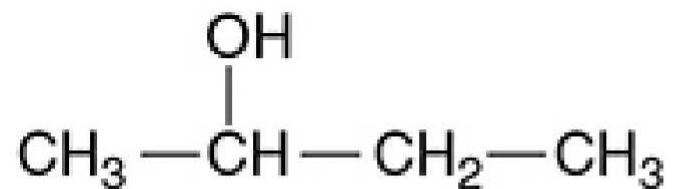
(D) ^{1}H

Q49

Cycloalkanes are hydrocarbons with the general formula C_nH_{2n}. If a 14 g sample of any alkene is combusted in excess oxygen, how many moles of water will form?
(A) 14 moles
(B) 2.0 moles
(C) 1.0 mole
(D) 28 moles

Q50

$$CH_3-\overset{\overset{\displaystyle OH}{\displaystyle |}}{CH}-CH_2-CH_3$$

The organic compound shown above would be classified as:
(A)   an organic base
(B)   an ether
(C)   an alcohol
(D)   an aldehyde

Q51

Which of the following is the one reaction that all organic compounds will undergo?
(A) neutralization
(B) precipitation
(C) combustion
(D) polymerization

Q52

A chemistry student prepares a solution of an unknown solid with a molar mass of 78.3 g/mol. She prepares the solution by dissolving 2.50 g of the unknown substance in 100.0 g of water. Which of the following procedures could she use to determine whether the unknown substance is an electrolyte?

(A) She could measure the specific heat of the solution.

(B) She could measure the volume of the solution.

(C) She could measure the freezing point of the solution.

(D) She could determine the specific heat of the solution.