AP Chemistry Midterm Review Name Key

***Refer to old practice tests as well!**

Multiple Choice

1. The diagram below shows a section of a 50.00 mL burette containing a colorless solution.
   The reading indicated on the burette is closest to
   A) 14.50
   B) 14.58
   C) 15.42
   D) 15.50

2. Which number has the greatest number of significant figures?
   A) 965. 3
   B) 0.440 3
   C) 100.0 4
   D) 0.00070 2
   E) 2.22×10^1 3

3. A buret that has volume markings at 0.1 mL intervals should be read to the nearest…
   A) mL.
   B) half mL.
   C) tenth of a mL.
   D) hundredth of a mL.
   E) thousandth of a mL.

4. A digital analytical balance had a readout when "tared" of 0.0000 g. How many significant figures would your weight data permit if the object you were weighing had a mass greater than 1 g, but less than 10 grams?
   A) 7
   B) 6
   C) 5
   D) 4
   E) 3

5. The densities of ethylene glycol, water and wood alcohol are 1.11 g/mL, 1.00 g/mL and 0.79 g/mL respectively. Suppose an object floats in water and ethylene glycol but sinks when placed in wood alcohol. Which could be the density of the object?
   A) 1.22 g/mL
   B) 1.11 g/mL
   C) 1.05 g/mL
   D) 0.92 g/mL
   E) 0.75 g/mL

   $0.79 < d < 1$

6. A starch molecule contains 500 glucose units. If the mass of glucose is 180 g/mol, then the molar mass of the starch molecule would be…
   A) 8982 g/mol
   B) 81018 g/mol
   C) 90000 g/mol
   D) 98982 g/mol

   $500 \times \frac{180\,g}{mol} =$

7. Xylose is a compound that has five carbon atoms in each molecule and contains 40% carbon by mass. What is the molar mass of xylose? 60g
   A) 30
   B) 67
   C) 150
   D) It cannot be determined without further information.

   $60g = 0.4x$

8. Serotonin ($C_{10}H_{12}N_2O$; molar mass = 176 g mol^{-1}) is a compound that conducts nerve impulses in the brain and muscles. A sample of spinal fluid from a volunteer in a study was found to contain a serotonin concentration of 1.5 ng L^{-1} (1.5 nanograms per liter). How many molecules of serotonin are there in one milliliter of the spinal fluid?
   A) 5.13×10^9
   B) 9.03×10^{14}
   C) 5.13×10^{27}
   D) 9.03×10^{29}

   $1\,mL \times \frac{1\,L}{1000\,mL} \times \frac{1.5\,ng}{1\,L} \times \frac{1\,g}{10^9\,ng} \times \frac{1\,mol}{176\,g} \times \frac{6.02 \times 10^{23}}{1\,mol}$

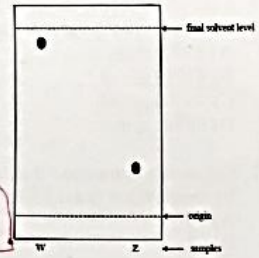
9. An analysis is carried out on sample of an unknown gas. The density of the gas is 2.86 grams per liter at STP. The molecular formula of the gas is…
   A) HCl
   B) Cl_2
   C) NO_2
   D) SO_2

   $\frac{2.86\,g}{L} \times \frac{22.4\,L}{1\,mol}$

10. What volume does 0.0685 mole of gas occupy at STP?
    A) 0.3707
    B) 0.7515
    C) 1.53
    D) 3.06

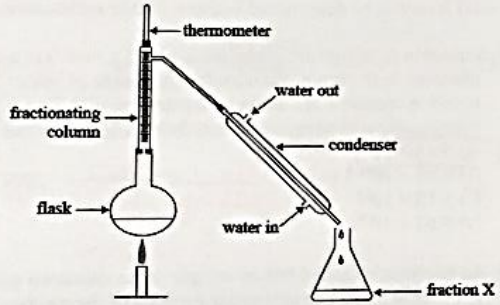
    $0.0685\,mol \times \frac{22.4\,L}{1\,mol}$

11. Two different food dye samples, W and Z, were compared using thin layer chromatography as shown below:



A) Z is more attracted to the solvent than W and has a lower R_f value.
B) Z is more attracted to the solvent than W and has a higher R_f value.
C) W is more attracted to the solvent than Z and has a lower R_f value.
D) W is more attracted to the solvent than Z and has a higher R_f value.

12. In a laboratory experiment, a mixture of alkanes was separated into components by fractional distillation using the following apparatus.



The first fraction collected is fraction X, then fraction Y then fraction Z. From this information we can deduce that...

A) fraction Y is more volatile than Z.
B) fraction Y has a higher molar mass than Z.
C) fraction X has a higher boiling point than Y and Z.
D) fraction Z has stronger covalent bonds in its molecules than X and Y.

$$2\ C_7H_5N_3O_6 \rightarrow 7\ C + 7\ CO + 3\ N_2 + 5H_2O$$

13. How many moles of nitrogen gas (N_2) could be produced in the complete decomposition of 4.0 moles of TNT, $C_7H_5N_3O_6$?

A) 2.0 moles
B) 2.5 moles
C) 3.0 moles
D) 4.0 moles
E) 6.0 moles

$4 \text{ mol TNT} \times \frac{3 \text{ mol } N_2}{2 \text{ mol TNT}}$

$N_2 + 3H_2 \rightarrow 2NH_3$

14. Nitrogen gas and hydrogen gas react to form ammonia, NH_3. How many moles of ammonia are produced by the reaction of 1.0 mol of nitrogen gas with 1.5 mol hydrogen gas?

A) 1.0 mol ammonia
B) 1.25 mol ammonia
C) 1.5 mol ammonia
D) 2.0 mol ammonia
E) 2.3 mol ammonia

$0.5\ N_2 + 1.5\ H_2 \rightarrow NH_3$

15. If 8 mol of acetylene (C_2H_2) are combined with 10 mol of hydrogen gas to form ethane (C_2H_6), how many moles of a reactant remain if the reaction proceeds as fully as possible?

A) Both reactants are completely consumed in the reaction.
B) 2 mol hydrogen remain
C) 3 mol hydrogen remain
D) 2 mol acetylene remain
E) 3 mol acetylene remain

$C_2H_2 + 2H_2 \rightarrow C_2H_6$

$5\ C_2H_2 + 10\ H_2 \rightarrow 5\ C_2H_6$

16. When 1.0 mole of Cu_3FeS_3 and 1.0 mole of O_2 are mixed and allowed to react according to the equation: $2\ Cu_3FeS_{3\,(s)} + 7\ O_{2\,(g)} \rightarrow 6\ Cu_{(s)} + 2\ FeO_{(s)} + 6\ SO_{2\,(g)}$

A) no reagent is in excess.
B) 5 mole of O_2 is in excess.
C) 5/7 mole of Cu_3FeS_3 is in excess.
D) 2/7 mole of Cu_3FeS_3 is in excess.

$\frac{2}{7} Cu_3FeS_3 + O_2 \rightarrow \frac{6}{7} Cu + \frac{2}{7} FeO + \frac{6}{7} SO_2$

$1 - \frac{2}{7}$

17. Iridium (symbol Ir, atomic weight 192.217 amu) consists of only two naturally occurring isotopes. One of these isotopes is iridium-191, accounting for 37% of the iridium on earth. Which must be the other isotope?

A) Ir-77
B) Ir-189
C) Ir-190
D) Ir-192
E) Ir-193

$191 \times .37 + \_\_ \times .63 = 192.17$

18. The compounds XSO_4 and Na_2Y suggest the existence of:

A) XY
B) YX
C) X_2Y
D) XY_2
E) XY_3

+2 -2 +1 -2

19. A doubly charged ion has the following properties: full 3d and 4d orbitals, no 5p electrons, ion in the ground electronic state. The ion could be...

A) S^{2-}
B) Sn^{2+}
C) Cr^{2+}
D) Se^{2-}
E) Ba^{2+}

20. A neutral atom has the electron configuration: $1s^2 2s^2 2p^6 3s^1 3p^1$

A) The atom is in an excited electronic state.
B) This atom cannot be identified by its electronic configuration.
C) This configuration violates the Pauli Exclusion Principle.
D) This configuration cannot exist since it is not a noble gas configuration.
E) Atoms with this configuration can be found in both Group 2A(12) and 3A(13).

21. A species, isoelectronic to Ar, is smaller than the Cl^- ion, but bigger than the Ca^{2+} ion. The species could be…

18e >17p <20p

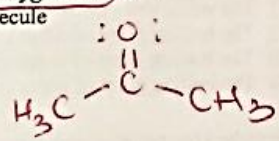
A) S^{2-}
B) Na^+
C) K^+
D) P^{3-}
E) Ra^{2+}

22. Which can be described as containing both significant covalent and ionic bonding?

A) Na_3PO_4
B) NaCN
C) KNO_3
D) $(NH_4)_2CO_3$
E) All of the above contain examples of covalent and ionic bonding

23. Acetone has the formula CH_3COCH_3 where the three carbons form a chain. The best bonding description of the central carbon atom to the oxygen atom is…

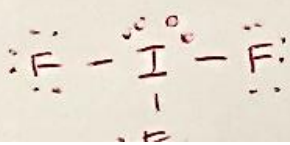
A) single bond: pi type above and below plane of molecule
B) double bond: one sigma and one pi type
C) double bond: two pi bonds
D) double bond: two sigma bond
E) triple bond: one sigma, two pi



24. What are the hybrid orbitals of iodine in the molecule IF_3?

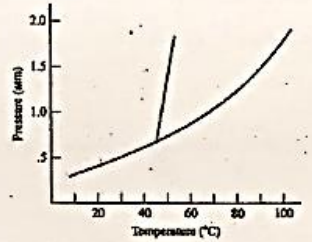
28 vale⁻

A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2



AX_3E_2

The following 3 questions refer to the phase diagram below of a pure substance.



A) Freezing
B) Melting
C) Sublimation
D) Condensation
E) Vaporization

25. If the temperature increases from 40° C to 60° C at a pressure of 1.5 atmospheres, which process is occurring? B

26. If the temperature increases form 20° C to 60° C at a pressure of 0.5 atmospheres, which process is occurring? C

27. If the pressure increases from 0.5 to 1.0 atmospheres at 60° C, which of the process is occurring? D

28. Under which of the following condition of temperature and pressure would 1.0 mol of the real gas $CO_2(g)$ behave most like an ideal gas?

	Temperature (K)	Pressure (atm)
A)	100	0.1
B)	100	100
C)	800	0.1
D)	800	1
E)	800	100

Use the choices below for the following 4 questions.

A) H_2
B) He
C) O_2
D) N_2
E) CO_2

29. A 1 mole sample of this gas occupying 1 liter will have the greatest density. E

30. At a given temperature, this gas will have the greatest rate of effusion. A

31. The molecules of this gas contain polar bonds. E

32. The molecules of this gas contain triple bonds. D

33. A helium balloon is inflated to a volume of 5.65 L and a pressure of 10.2 atm at a temperature of 25 °C. The amount of helium, in moles, in the balloon is

A) 0.023
B) 0.276
C) 2.36
D) 27.95

$(10.2)(5.65) = n(.0821)(298)$

34. A balloon occupies 4.0 L at 20°C. How cold must it be to reduce the volume to one fourth the original size? Assume the pressure stays the same.

A) 0°C
B) 0.25°C
C) 5°C
D) 20 K
E) 73 K

$\frac{4}{293} = \frac{1}{T}$

35. A mixture of He and Ar, whose mole fraction of He is 0.400, is collected over water at 29°C (vapor pressure 30.0 mm Hg). If the total pressure exerted by the gas mixture is 1.00 atm, what is the partial pressure of Ar in mm Hg?

A) 438
B) 292
C) 456
D) 316
E) 474

760 mm Hg

He + Ar = 730

$P_{Ar} = .6 \times 730$

36. A gas sample with a mass of 10 grams occupies 6.0 liters and exerts a pressure of 2.0 atm at a temperture of 26°C. Which of the following expressions is equal to the molecular mass of the gas. The gas constant, R, is 0.08 (L-atm) / (mol-K)

A) $\frac{(10)(0.08)(299)}{(2.0)(6.0)}$ g/ mol
B) $\frac{(299)(0.08)}{(10)(2.0)(6.0)}$ g/ mol
C) $\frac{(2.0)(6.0)(299)}{(10)(0.08)}$ g/ mol
D) $\frac{(10)(2.0)(6.0)}{(299)(0.08)}$ g/ mol
E) $\frac{(2.0)(6.0)}{(10)(299)(0.08)}$ g/ mol

$n = \frac{(2.0)(6.0)}{(.08)(299)}$

$MM = \frac{g}{mol} = \frac{(10)(.08)(299)}{(2.0)(6.0)}$

37. Which of the following assumptions is (are) valid based on the kinetic molecular theory?

I. gas molecules have negligible volume
II. gas molecules exert no attractive forces
III. the temperature of a gas is directly proportional to its kinetic energy

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

38. A gas sample contains 0.1 moles of oxygen and 0.4 moles of nitrogen. If the sample is at STP, what is the partial pressure due to nitrogen?

A) 0.1 atm
B) 0.2 atm
C) 0.5 atm
D) 0.8 atm
E) 1.0 atm

$\frac{.4}{.5} \times 1$

39. One possible reaction that occurs when trinitrotoluene (TNT), $C_7H_5N_3O_6$, explodes is:

$2\ C_7H_5N_3O_{6\,(s)} \rightarrow 2\ C_{(s)} + 12\ CO_{(g)} + 5\ H_{2\,(g)} + 3\ N_{2\,(g)}$

When one mole of TNT explodes the total volume of the gases produced from this reaction, measured at 27 °C and 1.00×10^2 kPa, is closest to…

A) 0.249 L
B) 22.7 L
C) 249 L
D) 274 L

$(100)V = (10)(8.315)(300)$

40. At a pressure of 1 atm, water boils at 100°C. How would an increase in pressure affect the temperature at which water boils?

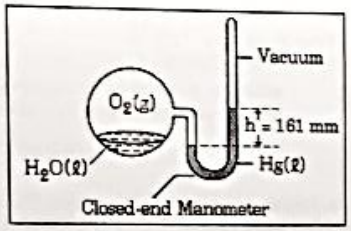
A) The water will boil at a higher temperature.
B) The water will boil at a lower temperature.
C) The boiling point of water is independent of pressure.
D) The boiling point of water is only dependent on pressure at the triple point.
E) The boiling point of water is only dependent on pressure at the critical point.

41. At standard temperature and pressure, a 0.50 mol sample of H_2 gas and a separate 1.0 mol sample of O_2 gas have the same

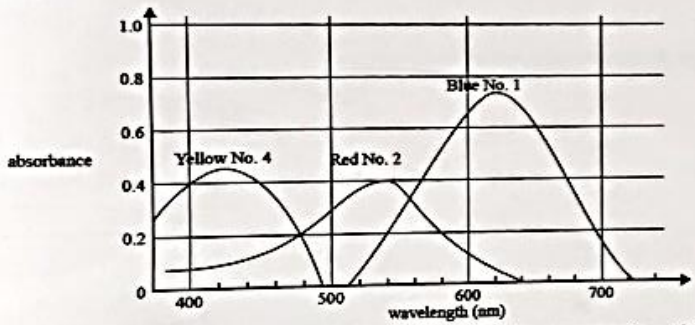
A) average molecular kinetic energy
B) average molecular speed
C) volume
D) effusion rate
E) density

42. The system shown in the picture above is at equilibrium at 28°C. At this temperature, the vapor pressure of water is 28 mmHg. The partial pressure of $O_2(g)$ in the system is …

A) 28 mmHg
B) 56 mmHg
C) 133 mmHg
D) 161 mmHg
E) 189 mmHg



43. The graph shows the absorption spectra of three food dyes: Blue No. 1, Red No. 2 and Yellow No. 4.



Which one of the following is the best wavelength to determine the concentration of Red No. 2 dye in a solution containing a mixture of all three dyes?

A) 430 nm
B) 500 nm
C) 540 nm
D) 620 nm

44. Which of the following solutions has the lowest freezing point?

A) 0.10 *m* $ZnSO_4$ i = 2
B) 0.10 *m* CoI_2 i = 3
C) 0.10 *m* $C_6H_{12}O_6$, glucose i = 1
D) 0.10 *m* NaI i = 2
E) 0.10 *m* AlI_3 i = 4

45. 15.0 mL of 10.0 M HCl is added to 60.0 mL of deionized water. The concentration of the diluted acid is…

A) 3.33 M
B) 2.50 M
C) 2.00 M
D) 0.500 M

(15)(10) = (75) M

46. About how many milliliters of 6.0 M HCl must be diluted to obtain 1.0 L of 2.5 M HCl?

A) 133 mL
B) 250 mL
C) 400 mL
D) 420 mL
E) 840 mL

(6) V = (2.5)(1)

47. Which of the following, when placed in water, would likely result in an aqueous solution that readily conducts electricity?

A) CH_3OH
B) $BaSO_4$
C) Na_3PO_4
D) AgCl
E) All of the above

48. If 20. mL of a 0.10 M silver nitrate solution is added to 80. mL of a 0.10 M calcium chloride solution, what is the final concentration of chlorine ion?

A) 0.08 M
B) 0.10 M
C) 0.14 M
D) 0.16 M
E) 0.18 M

$2\,AgNO_3 + CaCl_2 \rightarrow Ca(NO_3)_2 + 2\,AgCl$

.002 mol .008 mol

.002 mol $AgNO_3$ $\frac{1\ CaCl_2}{2\ AgNO_3}$ = .001 mol $CaCl_2$ reacted

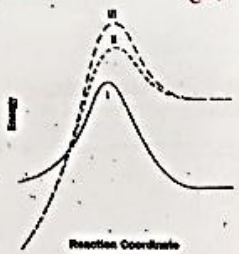
$2\times \frac{.007 \text{ mol leftover}}{.1\ L}$

49. When a gas condenses…

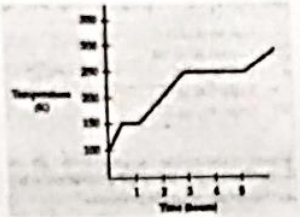
A) heat is absorbed and entropy decreases.
B) heat is released and entropy decreases.
C) heat is absorbed and entropy increases.
D) heat is released and entropy increases.
E) heat is neither absorbed or released.

50. Which reaction(s) is/ are exothermic?

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



51. In an experiment, a solid 1 molar sample of Substance A was gradually heated by a source of constant energy for several hours and the temperature was measured periodically. At the end of the heating period, Substance A had been converted to the gas phase. The heating curve produced by this experiment is shown.



Based on the data given in the heating curve, which of the following statements is NOT true regarding Substance A?

A) The boiling point of Substance A is 250 K.
B) The freezing point of substance A is 150 K.
C) The heat of vaporization of Substance A is greater than the heat of fusion.
D) Substance A is a liquid at room temperature.
E) The intermolecular forces exhibited by Substance A are weaker than those of water.

52. What set of temperature and pressure conditions are required to drive the following reaction to produce products? $(CO_{2\,(g)} + Ca(OH)_{2\,(s)} \rightarrow CaCO_{3\,(s)} + H_2O_{(l)})$ $\Delta H_{rxn} = -113kJ$

A) increase in temperature and increase in pressure
B) increase in temperature and decrease in pressure
C) decrease in temperature and decrease in pressure
D) decrease in temperature and increase in pressure
E) This reaction cannot be forced to produce products.

53. At what temperature will a reaction become spontaneous if ΔH for the reaction is –75 kJ and ΔS is +10.5 J/K ?

A) 7100 K
B) 7100 C
C) 0.710 K
D) The reaction is never spontaneous.
E) The reaction is spontaneous at all temperatures.

Free Response 2008 Form A form B #3

1. A 0.150 g sample of solid lead(II) nitrate is added to 125 mL of 0.100 *M* sodium iodide solution. Assume no change in volume of the solution. The chemical reaction that takes place is represented by the following equation.

$$Pb(NO_3)_2(s) + 2\,NaI(aq) \rightarrow PbI_2(s) + 2\,NaNO_3(aq)$$

a. List an appropriate observation that provides evidence of a chemical reaction between the two compounds.

A precipitate forms that is different in appearance from the solid reactant

b. Calculate the number of moles of each reactant.

$0.150g\ Pb(NO_3)_2 \times \frac{1\ mol\ Pb(NO_3)_2}{331.22g} = 4.53\times10^{-4}$ mol $Pb(NO_3)_2$

$0.100\ M \times 0.125\ L\ NaI = 0.0125$ mol NaI

c. Identify the limiting reactant. Show calculations to support your identification.

$Pb(NO_3)_2$ is the limiting reactant.

$4.53\times10^{-4}\ Pb(NO_3)_2 \times \frac{2\ NaI}{1\ Pb(NO_3)_2} = 9.06\times10^{-4}$ mol NaI

only 9.06×10^{-4} mol NaI is used when all of the $Pb(NO_3)_2$ is reacted.

d. Calculate the molar concentration of $NO_3^-(aq)$ in the mixture after the reaction is complete.

4.53×10^{-4} mol $Pb(NO_3)_2 \times \frac{2\ mol\ NO_3^-(aq)}{1\ Pb(NO_3)_2} = 9.06\times10^{-4}$ mol NO_3^-

$\frac{9.06\times10^{-4}\ mol}{.125\ L} = 0.00725\ M$

2. Answer the following problems about gases. 2007 part A form B #2

The average atomic mass of naturally occurring neon is 20.18 amu. There are two common isotopes of naturally occurring neon as indicated in the table below.

Isotope	Mass (amu)
Ne-20	19.99
Ne-22	21.99

a. Using the information above, calculate the percent abundance of each isotope.

$19.99x + 21.99(1-x) = 20.18$

$19.99x + 21.99 - 21.99x = 20.18$

$x = 0.905$

$\therefore$ 90.5% Ne-20, 9.5% Ne-22

b. Calculate the number of Ne-22 atoms in a 12.55 g sample of naturally occurring neon.

$12.55\text{g Ne} \times \frac{1\text{ mol Ne}}{20.18\text{g Ne}} \times \frac{0.095\text{ mol Ne-22}}{1\text{ mol Ne}} \times \frac{6.02\times10^{23}\text{ atoms}}{1\text{ mol Ne-22}}$

3.6×10^{22} Ne-22 atoms

c. A major line in the emission spectrum of neon corresponds to a frequency of $4.34\times10^{14}\ s^{-1}$. Calculate the wavelength, in nanometers, of light that corresponds to this line.

$c = \nu\lambda$

$3\times10^{8}\ m/s = (4.34\times10^{14}\ s^{-1})\lambda$

$\lambda = 6.91\times10^{-7}$ m

$= 691$ nm

In the upper atmosphere, ozone molecules decompose as they absorb ultraviolet (UV) radiation, as shown by the equation below. Ozone serves to block harmful ultraviolet radiation that comes from the Sun.

$$O_3(g) \xrightarrow{UV} O_2(g) + O(g)$$

A molecule of $O_3(g)$ absorbs a photon with a frequency of $1.00\times10^{15}\ s^{-1}$.

i. How much energy, in joules, does the $O_3(g)$ molecule absorb per photon?

$E = h\nu$

$= (6.626\times10^{-34}\ Js)(1.00\times10^{15}\ s^{-1})$

$= 6.63\times10^{-19}$ J

ii. The minimum energy needed to break an oxygen-oxygen bond in ozone is 387 kJ mol^{-1}. Does a photon with a frequency of $1.00\times10^{15}\ s^{-1}$ have enough energy to break this bond? Support your answer with a calculation.

$\frac{6.63\times10^{-19}\text{ J}}{1\text{ photon}} \times \frac{6.02\times10^{23}\text{ phot.}}{1\text{ mol}} \times \frac{1\text{ kJ}}{1000\text{ J}} = 399\ \frac{\text{kJ}}{\text{mol}}$

Yes, 399 > 387, so the bond can be broken

2006 I>

3. Suppose that a stable element with atomic number 119, symbol Q, has been discovered.

a. Write the ground-state electron configuration for Q, showing only the valence-shell electrons.

$8s^1$

b. Would Q be a metal or a nonmetal? Explain in terms of electron configuration.

metal. Alkali metals have 1 valence electron in the s shell

c. On the basis of periodic trends, would Q have the largest atomic radius in its group or would it have the smallest? Explain in terms of electronic structure.

Largest. Radius increases going down a group due to the ~~additional~~ ~~value~~ increase in occupied energy levels

d. What would be the most likely charge of the Q ion in stable ionic compounds?

+1

e. Write a balanced equation that would represent the reaction of Q with water.

f. Assume that Q reacts to form a carbonate compound.

a. Write the formula for the compound formed between Q and the carbonate ion, CO_3^{2-}.

Q_2CO_3

b. Predict whether or not the compound would be soluble in water. Explain your reasoning.

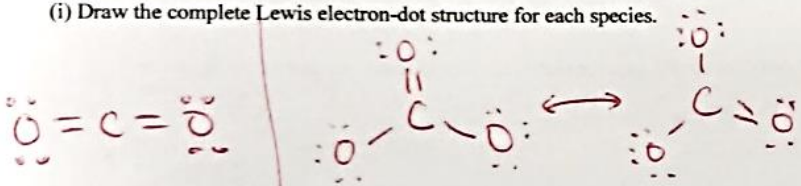
It would be soluble in water since all group 1 ions are soluble in water.

1999 D

4. Answer the following questions using principles of chemical bonding and molecular structure.

a. Consider the carbon dioxide molecule, CO_2, and the carbonate ion, CO_3^{2-}.

(i) Draw the complete Lewis electron-dot structure for each species.

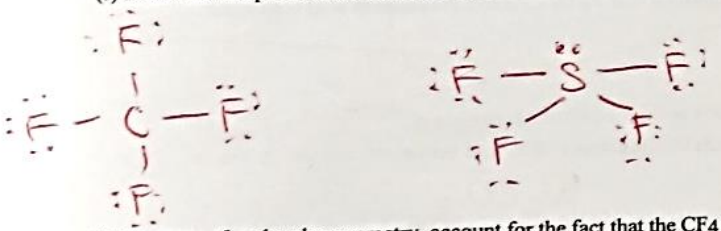


(ii) Account for the fact at the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2.

CO_2 has double bonds whereas the C-O bonds in CO_3^{2-} exist as an average of 3 resonance structures. The bond length in resonance forms is longer than in double bonds.

b. Consider the molecules CF_4 and SF_4.

(i) Draw the complete Lewis electron-dot structure for each molecule.



(ii) In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

CF_4 is tetrahedral and completely symmetrical.

The lone pair on S in SF_4 causes the molecular geometry to not be symmetrical.

5. When 1.758 g of an unknown hydrocarbon ($C_xH_yO_z$) is combusted, 2.578 g of carbon dioxide and 1.055 g of water are produced. The reaction occurs at 298 K.

a. Determine the empirical formula for the hydrocarbon.

C = 0.05858 mol = .7035 g C

H = 0.11709 mol = .11826 g H

O = .0585 mol = .93624 g O

$\boxed{CH_2O}$

b. Determine the molecular formula for the hydrocarbon, if the molar mass is 180 g/mol.

MF		180
EF	CH_2O	30

$\frac{180}{30} = 6$

$\boxed{C_6H_{12}O_6}$

c. Write the heat of formation equation for one mole of the above hydrocarbon.

d. Using the above heat of formation equation, whose $\Delta H = -1271$ kJ/mol, along with the below heat of formation equations provide the following:

$C + O_2 \rightarrow CO_2$ $\quad \Delta H = -393.5$ kJ/mol

$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$ $\quad \Delta H = -285.8$ kJ/mol

i. The balanced overall combustion reaction equation for the hydrocarbon.

$1\ C_6H_{12}O_6 + 9\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$

ii. The overall heat of reaction.

$\Delta H = (6 \times -393.5 + 6 \times -285.8) - (-1271)$

$\boxed{\Delta H = -2806 \text{ kJ}}$

e. If the entropy for the above reaction is + 247 J/mol calculate ΔG for the combustion reaction.

$\Delta G = \Delta H - T\Delta S = -2806 - 298(.247)$

$\boxed{= -2880 \text{ kJ/mol}}$

f. What do the magnitudes of ΔH, ΔS, and ΔG suggest about the temperature dependence on the spontaneity for this reaction? (At what temperatures would the reaction be spontaneous vs. nonspontaneous?)

The reaction will ~~always~~ be spontaneous at any temperature

1995 B

6. Propane, C_3H_8, is a hydrocarbon that is commonly used as fuel for cooking.

(a) Write a balanced equation for the complete combustion of propane gas, which yields $CO_2(g)$ and $H_2O(l)$.

$$1\,C_3H_8 + 5\,O_2 \rightarrow 3\,CO_2 + 4\,H_2O$$

(b) Calculate the volume of air at 30°C and 1.00 atmosphere that is needed to burn completely 10.0 grams of propane. Assume that air is 21.0 percent O_2 by volume.

$$10\text{ g } C_3H_8 \times \frac{1\text{ mol}}{44.11\text{ g}} \times \frac{5\ O_2}{1\ C_3H_8} = 1.13\text{ mol } O_2$$

$$(1.00\text{ atm})V = (1.13\text{ mol})(.0821)(303)$$

$$V = 28.2\text{ L } O_2 \times \frac{100\text{ L air}}{21\text{ L } O_2} = \boxed{134\text{ L air}}$$

(c) The heat of combustion of propane is -2,220.1 kJ/mol. Calculate the heat of formation, $\Delta H°_f$, of propane given that $\Delta H°_f$ of $H_2O(l)$ = -285.3 kJ/mol and $\Delta H°_f$ of $CO_2(g)$ = -393.5 kJ/mol.

$$-2220.1 = [3(-393.5) + 4(-285.3)] - [H_f + 5(0)]$$

$$\boxed{H_f = -101.6\text{ kJ/mol}}$$

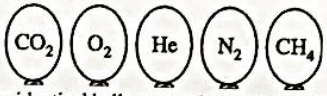
(d) Assuming that all of the heat evolved in burning 30.0 grams of propane is transferred to 8.00 kilograms of water (specific heat = 4.18 J/g·K), calculate the increase in temperature of water.

$$30\text{ g } C_3H_8 \times \frac{1\text{ mol } C_3H_8}{44.11\text{ g}} \times \frac{2220.1\text{ kJ}}{1\text{ mol } C_3H_8} = 1510\text{ kJ} = 1510000\text{ J}$$

$$1510000\text{ J} = (8000\text{ g})(4.18\ \tfrac{\text{J}}{\text{g K}})\Delta T$$

$$\boxed{\Delta T = 45.2°}$$

1996 D



7. Represented above are five identical balloons, each filled to the same volume at 25°C and 1.0 atmosphere pressure with the pure gases indicated.

(a) Which balloon contains the greatest mass of gas? Explain.

CO_2. All balloons have the same # of moles of gas, so the gas with the heaviest molar mass is found in the balloon with the heaviest mass

(b) Compare the average kinetic energies of the gas molecules in the balloons. Explain.

The average kinetic energies of the gas molecules are the same in all the balloons since they are at the same temperature.

(c) Which balloon contains the gas that would be expected to deviate most from the behavior of an ideal gas? Explain.

CO_2. It is the largest molecule and therefore the strongest intermolecular forces exist between its molecules

(d) Twelve hours after being filled, all the balloons have decreased in size. Predict which balloon will be the smallest. Explain your reasoning.

He. It is the lightest gas and will therefore effuse out of the balloon at the fastest rate.

8. Butane, chloroethane, acetone, and 1-propanol all have approximately the same molecular weights. Data on their boiling points and solubilities in water are listed in the table below.

Compound	Formula	Boiling Pt.(°C)	Solubility in water
Butane	$CH_3CH_2CH_2CH_3$	0	insoluble
Chloroethane	CH_3CH_2Cl	12	insoluble
Acetone	$CH_3\overset{O}{\overset{\|}{C}}CH_3$	56	completely miscible
1-Propanol	$CH_3CH_2CH_2OH$	97	completely miscible

On the basis of molecular polarity and/or hydrogen bonding, explain in a qualitative way the differences in the

(a) boiling points of butane and chloroethane.

chloroethane has stronger attractive forces between its molecules (both london dispersion + dipole-dipole forces) so it has a higher boiling point

(b) water solubilities of chloroethane and acetone.

Acetone is capable of hydrogen bonding w/ H_2O, so will mix with water more easily.

(c) water solubilities of butane and 1-propanol.

Butane is completely symmetrical + nonpolar, therefore will not dissolve in water. 1-propanol is polar due to the -OH group, so will mix with water.

(d) boiling points of acetone and 1-propanol.

1-propanol has stronger attractive forces between its molecules.