AP chemistry January 2014 Final exam.

1-5 Base your responses on the table of first and second ionization energies below, which apply to the elements in Period 3 of the periodic table. Unknown elements A, B, and C are NOT listed in order of atomic number.

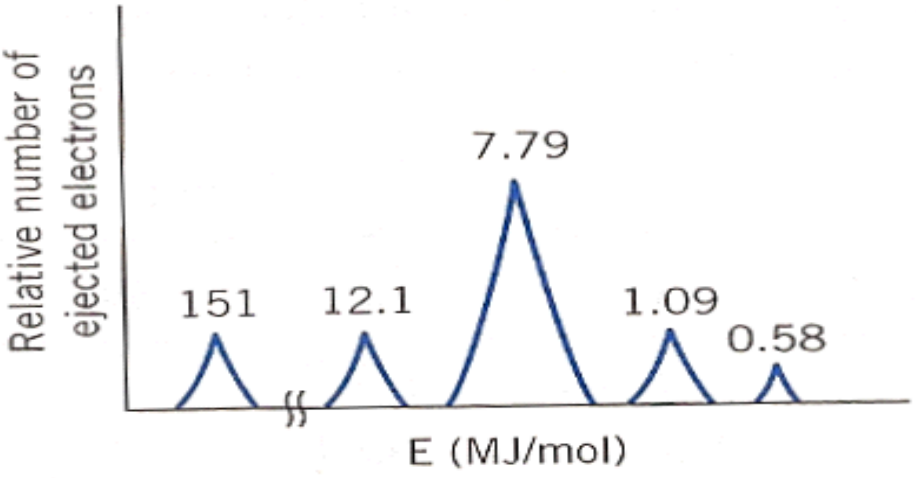
Element	I_1 (kJ/mol)	I_2 (kJ/mol)
P	1012	1907
S	1000	2252
A	495	4562
B	1251	2298
C	1521	2666

1. The best explanation for the fact that sulfur has a lower first ionization energy than phosphorous is that
(A) There is extra stability in the half filled p sublevel in the phosphorous atom
(B) There are coulombic repulsions in one of the p orbitals in sulfur that do not occur in phosphorous
(C) Sulfur has a greater nuclear charge than phosphorous
(D) Phosphorous has a greater nuclear charge than sulfur

2. The best explanation for the fact that sulfur has a **higher** second ionization energy than phosphorous is that
(A) There is extra stability in the half filled p sublevel on the sulfur 1+ ion.
(B) There are coulombic repulsions in the p orbitals of phosphorous that do not occur in sulfur
(C) Sulfur has a greater nuclear charge than phosphorous
(D) Phosphorous has a greater nuclear charge than sulfur

3. The most probable compound formed between element A and element B is
(A) AB (B) A_2B (C) AB_2 (D) A_3B

The photoelectron spectrum (PES) of one of the period 3 elements is sketched below:



4. Which element is most likely to have produced this spectrum?
(A) Mg (B) Al (C) Si (D) P

5. Selenium, Se, is located directly below sulfur on the periodic table. How would data for selenium compare with that of sulfur?
(A) The first ionization energy of selenium would be lower than that of sulfur and the PES of selenium would have three additional peaks.
(B) The first ionization energy of selenium would be higher than that of sulfur and the PES of selenium would have three additional peaks.
(C) The first ionization energy of selenium would be lower than that of sulfur and the PES of selenium would have two additional peaks.
(D) The first ionization energy of selenium would be higher than that of sulfur and the PES of selenium would have two additional peaks.

6. How many unpaired electrons are there on a ground state Co^{3+} ion?
A) 2 B) 3 C) 4 D) 5

7. If an element has the electron configuration 2-8-13-1, how many of the electrons are in the 3 **d** sublevel? A) 4 B) 5 C) 6 D) 13

8. The amount of heat that will cause a sample of water to become 1 degree warmer, will cause the same mass of lead to become 30 degrees warmer. The best conclusion that can be drawn from this information is that
A) the specific heat of lead is 30 times greater than that of water
B) the specific heat of water is 30 times greater than that of lead
C) lead is 30 times denser than water
D) the molar mass of lead is 30 times the molar mass of water

9-10

A student is given four bottles, each containing one of the following four liquids:

1. Ethanol, C_2H_5OH 2. dimethyl ether, CH_3OCH_3

3. carbon tetrachloride, CCl_4 4. propanone, CH_3COCH_3

The student wishes to identify each liquid, based on its physical properties.

9. A few drops of each liquid are added to separate test tubes containing some water.
Which of the four liquids can be identified based on this experiment?
A) ethanol B) dimethyl ether C) carbon tetrachloride D) propanone

10. The student tests the boiling point of each liquid and finds that ethanol has the highest normal boiling point of the four . This is due to the fact that
A) ethanol has stronger London dispersion forces than the other liquids
B) ethanol has weaker London dispersion forces than the other liquids
C) ethanol is the only liquid of the four that shows hydrogen bonding between its molecules
D) ethanol is the only liquid of the four that is a dipole

11-12. The first ionization energy of sulfur is 1000 kJ/mol.

11. Which of the following reactions most accurately illustrate the meaning of this ionization energy? (I.E.) A) $S(s) + I.E. \rightarrow S^+(g) + e^-$
B) $S(g) + I.E. \rightarrow S^+(g) + e^-$ C) $S(g) + e^- \rightarrow S^-$ + I.E.
D) $S(s) \rightarrow S^+(g) + e^-$ + I.E.

12. In a plot of the P.E.S. of sulfur, the peak that appears at 1.0 MJ (megajoules)/mol would be A) the lowest peak at the lowest energy. B) the second highest peak, at the highest energy C) the lowest peak at the highest energy
D) the second highest peak at the lowest energy.

13. Which molecule or ion shows sp hybridization on a carbon atom?
A) HCN B) CO_3^{2-} C) HCHO D) C_2H_6

14. In which molecule or ion is the **electron** geometry on the central atom trigonal bipyramidal? A) SF_6 B) ICl_5 C) SF_4 D) NO_3-

15 to 18. The density of a solid object is often found by determining its mass, and then adding it to a measured volume of water to determine its volume. The data for such an experiment are: Mass of metal object: 32.40 grams

Volume of water:	31.4 mL
Volume of water + object	35.4 mL

15. The density of the object, expressed to the correct number of significant figures is
A) 8 g/mL B) 8.1 g/mL C) 8.0 g/mL D) 8.10 g/mL

16. Which two physical properties of the solid are most important in making this method of determining density feasible? The object should be
A) of a regular shape, and have a smooth surface
B) denser than water, and insoluble in water
C) insoluble in water, and have a regular shape
D) soluble in water, and have a smooth surface

17. The experiment is repeated with aluminum, which is only one third as dense as the object in the first experiment. If 32.40 grams of aluminum are added to the same 31.4 mL of water, what will be the final total volume?
A) 32.7 mL B) 35.4 mL C) 43.4 mL D) 106 mL

18. In the determination of the density of aluminum by this method, with the same equipment as in the data above, the number of significant figures in the determined density would be A) the same as in the first experiment, since the same equipment was used B) fewer than in the first experiment, because the density of the Al is smaller. C) greater than in the first experiment, because of the larger volume of the aluminum sample D) the same as in the first experiment because both objects are metals

21. Which of the following ions has the same number of electrons as Se^{2-} ?
(A) K^{+} (B) S^{2-} (C) Y^{3+} (D) I^{-}

22. In solid methane, CH_4. the forces between neighboring molecules are best described as (A) ionic bonds (B) covalent bonds (C) hydrogen bonds (D) London (dispersion) forces

23. A compound contains 46 % sulfur and 54 % fluorine by mass. The empirical formula of the compound is (A) SF (B) SF_2 (C) S_2F (D) SF_4

24. If 0.80 mol of H_2 and 0.30 mol of O_2 were to react as completely as possible to produce H_2O, what mass of reactant would remain?
(A) 0.20 grams of H_2 (B) 0.40 grams of H_2 (C) 1.00 grams of H_2
(D) 4.0 grams of O_2

substance	A	B	C	D
melting point	2600°C	146°C	334°C	419° C
electrical conductivity in solid state	non conductor	non conductor	non conductor	excellent
electrical conductivity in water	insoluble	non-electrolyte	strong electrolyte	insoluble

25. Based on the physical properties listed above, which of these substances might be glucose? A)A B)B C)C D)D

26. Which of these substances might be an ionic solid? A)A B)B C)C D) D

27. Substance A is likely to be the same type of solid as A) iodine
B) dry ice C) diamond D) tungsten

28. ___$Ca_3(PO_4)_2$ + ___ H_3PO_4 → ____$Ca(H_2PO_4)_2$

When the equation above is balanced using the smallest possible whole number coefficients, what is the coefficient for H_3PO_4 ?
(A) 6 (B) 2 (C) 3 (D) 4

29. Which represents an atom in an excited state?
(A) $1s^2 2s^2 2p^4$ (B) $1s^2 2s^2 2p^6 3s^2 3p^1$ (C) $1s^2 2s^2 2p^4 3s^2$ (D) $1s^2 2s^2 2p^6 3s^2 3p^5$

30. How many carbon atoms are there in 4.4 grams of C_3H_8 ?
A) 1.2×10^{23} B) 1.8×10^{23} C) 6.0×10^{22} D) 1.8×10^{24}

31. Equal masses of He and Ar are placed in a sealed container. What is the partial pressure of He if the total pressure in the container is 11 atm?
(A) 1 atm (B) 10 atm (C) 5.5 atm (D) 8 atm

32. Considering the properties of the halogens, successively, from fluorine to iodine we would expect to see an increase in which of the following properties?
I. electronegativity II. chemical reactivity III. dispersion forces

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

33. Which molecule is a non-dipole? A) XeF_4 B) SeF_4 C) CH_2Cl_2 D) ICl_3

34. The heat of formation of propane, $C_3H_8(g)$, is by definition the enthalpy change of which reaction?
(A) $C_2H_4(g) + CH_4(g) \rightarrow C_3H_8(g)$ (B) $3\ C(g) + 8\ H(g) \rightarrow C_3H_8(g)$
(C) $3\ C(s) + 8\ H(g) \rightarrow C_3H_8(g)$ (D) $3\ C(s) + 4\ H_2(g) \rightarrow C_3H_8(g)$

35. Paper chromatography is used to separate pigments into their colored components. In a particular experiment, water is used as the solvent, and a red dye moves the farthest up the filter paper in a given amount of time. This result would indicate that compared to the other components present, the red dye most likely has
A) a greater attraction both to the water and the filter paper
B) a weaker attraction for both the water and the filter paper
C) a greater attraction for the water, and a weaker attraction for the paper
D) a greater attraction for the paper, and a weaker attraction for the water

36. A spectrophotometer measures the absorbance of a colored solution. The measured absorbance varies A) directly with the molarity, and directly with the width of the solution in the cuvette. B) directly with the molarity, and inversely with the width of the solution in the cuvette. C) inversely with the molarity, and directly with the width of the solution in the cuvette. D) inversely with both the molarity and the width of the solution in the cuvette.

37. The value of $\Delta H°$ for the reaction below is -72 kJ. How much heat is released when 80.9 grams of HBr is formed in this reaction?

$H_2\ (g) + Br_2\ (g) \rightarrow 2HBr\ (g)$

A) 36 kJ B) 72 kJ C) 144 kJ D) 5800 kJ

38. Given the following reactions:

$Fe_2O_3\ (s) + 3CO\ (s) \rightarrow 2Fe\ (s) + 3CO_2\ (g)$ $\Delta H = -28.0$ kJ

$3Fe\ (s) + 4CO_2\ (s) \rightarrow 4CO\ (g) + Fe_3O_4\ (s)$ $\Delta H = +12.5$ kJ

What is the enthalpy of the reaction of Fe_2O_3 with CO, given below, in kJ ?

$3\ Fe_2O_3\ (s) + CO\ (g) \rightarrow CO_2\ (g) + 2\ Fe_3O_4\ (s)$

A) -59.0 B) 40.5 C) -15.5 D) -109

39. Which two particles have the same number of electrons, but a **different** electron configuration? A) V^{5+} and Ca^{2+} B) Ca and V^{3+} C) Ne and O^{2-}
D) Zn^{2+} and Ga^{3+}

40. What is the molarity of a solution that contains 4.00 g of NaOH in a volume of 250. mL ? A) 2.5 M B) 16 M C) 0.40 M D) 0.10 M

Free Response Questions

I. These questions are based on the gas phase reaction:

$S(g) + O_2(g) \rightarrow SO_2(g) \quad \Delta\mathring{H} = -576$ kJ

The following information is available:

ΔHf, the enthalpy of formation of $SO_2(g) = -297$ kJ/mol

Bond energies: O=O in O_2, 495 kJ

A. Why is the enthalpy change for the given reaction NOT equal to the enthalpy of formation of $SO_2(g)$?

B. Calculate the enthalpy of formation of S(g)

C. Calculate the average bond energy of the Sulfur-oxygen bonds in $SO_2(g)$

D. There is some disagreement about what the best way is to represent an SO_2 molecule. One possible Lewis structure results in octets, 8 valence electrons, around all three atoms.

i. Draw the Lewis dot structure of SO_2 that is described above.
ii. Explain why the sulfur - oxygen bonds are all of equal length
iii. Find the formal charge of the sulfur atom on the structure you have drawn

E. In another possible Lewis structure, the sulfur has an extended octer, and all of the atoms have formal charges of zero. Draw this Lewis structure.

F. The bond energy of an S-O single bond is 423 kJ/mol, while the bond energy of an S=O double bond is 525 kJ/mol. Based on these bond energies, which of the two Lewis structures appears to best represent an SO_2 molecule? Explain your choice.

II. A student performs two calorimetry experiments using a coffee cup "calorimeter." The purpose of the first experiment is to determine the molar heat of solution of ammonium nitrate. The student adds 100.0 mL of water to the coffee cup. The directions call for the addition of sufficient ammonium nitrate to produce a 1.00 molar solution.

A. How many grams of ammonium nitrate must be added to produce the desired solution?

B. The addition of the ammonium nitrate causes the temperature of the solution
to decrease from 24.0°C to 19.5°C. The density of the water is 0.997g/mL, and the specific heat of the resulting solution is 3.90J/mol°.

i. What is the total mass of the solution?

ii. What is the calculated heat of solution in kJ/mol of ammonium nitrate?

C. The procedure ignores any heat that was transferred to or from the coffee cup and to or from the thermometer. This omission produces an inaccuracy in the calculated heat of solution. Does it cause the value to be greater than the correct value, or less than the correct value? Explain your choice.

D. Why is this experiment conducted in a coffee cup, rather than in a glass beaker?

E. A second experiment is performed to find the specific heat of copper, in j/g°. A 20.0 gram sample of Cu is placed in a test tube in a water bath at 100°C.
After 20 minutes, the copper sample is poured into a coffee cup that contains 50.0 grams of water, initially at 20.0°C. The final temperature of the mixture is 22.8° C. The specific heat of water is 4.18 J/g°

i. How much heat was transferred to the water?

ii. Assuming that the same amount of heat was lost by the copper, calculate the specific heat of copper.

III. Magnesium reacts with dilute acids to produce hydrogen. If HCl is used, the reaction is $Mg(s) + 2\ HCl(aq) \rightarrow H_2(g) + MgCl_2(aq)$

0.0400 grams of Mg are placed in a jar to whichis added 50.0 mL of 2.00 molar HCl

A. Calculate the volume of hydrogen gas produced at a temperature of 25.0℃ and a pressure of 760.0 torr.

B. The hydrogen gas is often collected over water (by water displacement). In such a case, how would the volume of gas collected in this experiment be affected? Jusify your prediction.

C. Calculate

i. The moles of HCl consumed by the reaction, and

ii. the molarity of the remaining HCl after the reaction has gone to completion,

assuming that the volume of the solution does not change.

D. ΔH for the reaction above is -466 kJ/mol.

i. How much heat is produced when 0.0400 grams of Mg are reacted as shown?

ii. If 50.0 mL of 2.00 molar hydroiodic acid, HI, is used instead of the HCl, the same amount of heat is produced? Why do the two different acids produce the same amount of heat in this reaction?

iii. If acetic acid is used instead of HCl, the amount of heat produced is **different.** Explain why the reaction of Mg with acetic acid produces less heat per mole than the reaction with hydrochloric acid.

IV. Formic acid, HCOOH, is the simplest organic acid.

A. Draw a Lewis structure of HCOOH.

B. Indicate the hybridization on the carbon atom

C. When HCOOH reacts with bases, it forms the formate ion, $HCOO^-$.

Compare the bond lengths of the carbon-oxygen bonds in the formate ion with those in formic acid. Explain any differences.

V. SO_2 gas is added to a 10.0 liter inflexible container at 400. K.
The initial pressure of SO_2 is 14.0 atm, and then enough oxygen is added to increase the total gas pressure to 20.0 atm. The reaction $2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$ occurs at constant temperature.

A. Calculate the number of moles of O_2 gas in the vessel before any reaction occurs.

B. Assuming that the reaction goes to completion, calculate the pressure of the SO_2 remaining in the flask at 400. K

C. In fact, the reaction does not go to completion. After a certain amount of time, it is found that the total pressure in the flask, still at 400 K, has dropped to 18.0 atm. Determine the partial pressure of EACH of the three gases now in the mixture.