AP FINAL EXAM

Directions: Each set of lettered choices below refers to the numbered questions or statements immediately following it. Select the one lettered choice that best answers each question or best fit each statement and then fill in the corresponding oval on the answer sheet. A choice may be used once, or not al all in each set.

Questions 1 – 4

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

1. Can be used to predict that a gaseous carbon atom in its ground state is paramagnetic.

2. Explains the experimental phenomenon of electron diffraction.

3. Indicates than an atomic orbital can hold no more than two electrons.

4. Predicts that it is impossible to determine simultaneously the exact position and exact velocity of an electron.

Questions 5 – 7 refer to the following diatomic species.

(A) Li_2
(B) B_2
(C) N_2
(D) O_2
(E) F_2

5. Has the largest bond-dissociation energy

6. Has a bond order of 2

7. Contains 1 sigma and 2 pi bonds

8. In a molecule in which the central atom exhibits sp^3d^2 hybrid orbitals, the electron pairs are directed toward the corners of

   (A) a tetrahedron
   (B) a square-based pyramid
   (C) a trigonal bypyramid
   (D) a square
   (E) an octahedron

9. In which of the following compounds is the mass ratio of chromium to oxygen closest to 1.62 to 1.00?
   (A) CrO_3
   (B) CrO_2
   (C) Cr_2O
   (D) Cr_2O_3

10. ……Ag^+ +……AsH_3 (*g*) + ……OH^- → ……Ag(*s*) + ……H_3AsO_3 + ……H_2O

When the equation above is balanced with lowest whole-number coefficients, the coefficient for OH^- is

(A) 2
(B) 4
(C) 5
(D) 6
(E) 7

11. Correct the statements about alpha particles include which of the following?

I. They have a mass number of 4 and a charge of +2.
II. They are more penetrating than beta particles.
III. They are helium nuclei.

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

12. A sample of 0.0100 mole of oxygen gas is confined at 37°C and 0.216 atmosphere. What would be the pressure of this sample at 15°C and the same volume?

(A) 0.0876 atm
(B) 0.175 atm
(C) 0.201 atm
(D) 0.233 atm
(E) 0.533 atm

13. H_2 (*g*) + ½ O_2 (*g*) → H_2O (*l*) ΔH = -286 kJ

2 Na(*s*) + ½ O_2 (*g*) → Na_2 (*s*) ΔH = -414 kJ

Na (*s*) + ½ O_2 (*g*) + ½ H_2 (*g*) → NaOH (*s*) ΔH = -286 kJ

Based on the information above, what is the standard enthalpy change for the following reaction?

Na_2O(*s*) + H_2O(*l*) → 2 NaOH(*s*)

(A) –1125 kJ
(B) -978 kJ
(C) -722 kJ
(D) -150 kJ
(E) +275 kJ

14. Which of the following sets of quantum numbers (n, *l*, m_l, m_s) best describes the valence electron of the highest energy in a ground-state gallium atom (atomic number 31)?

(A) 4, 0, 0, 1/2
(B) 4, 0, 1, 1/2
(C) 4, 1, 1, 1/2
(D) 4, 1, 2, 1/2
(E) 4, 2, 0, 1/2

15. A hydrocarbon gas with an empirical formula CH_2 has a density of 1.88 grams per liter at 0^oC and 1.00 atmosphere. A possible formula for the hydrocarbon is

(A) CH_2
(B) C_2H_4
(C) C_3H_6
(D) C_4H_8
(E) C_5H_{10}

16. A sample of 3.30 grams of an ideal gas at 150.0^oC and 1.25 atmospheres pressure has a volume of 2.00 liters. What is the molar mass of the gas?
The gas constant, R, is 0.0821 (L x atm)/(mol x K).

(A) 0.0218 grams / mole
(B) 16.2 grams / mole
(C) 37.0 grams / mole
(D) 45.8 grams / mole
(E) 71.6 grams / mole

17. Samples of F_2 gas and Xe gas are mixed in a container of fixed volume. The initial partial pressure of the F_2 gas is 8.0 atmospheres and that of Xe is 1.7 atmospheres. When all the xenon gas has reacted, forming a solid compound, the pressure of the unreacted F_2 gas was 4.6 atmospheres. The temperature remained constant. What is the formula of the compound?

(A) XeF
(D) XeF_3
(E) XeF_4
(D) XeF_6
(E) XeF_8

18.

Closed-end Manometer

The system shown above is at equilibrium at 28^oC. At this temperature, the vapor pressure of water is 28 millimeters of mercury. The partial pressure of O_2 (*g*) in the system is

(A) 28 mm Hg
(F) 56 mm Hg
(G) 133 mm Hg
(D) 161 mm Hg
(E) 189 mm Hg

19.

mass of an empty container	3.0 grams
mass of the container plus the solid sample	25.0 grams
volume of the solid sample	11.0 cubic centimeters

The data above were gathered in order to determine the density of an unknown solid. The density of the sample should be *reported* as

(A) 0.5 g/cm^3
(B) 0.50 g/cm^3
(C) 2.0 g/cm^3
(D) 2.00 g/cm^3
(E) 2.27 g/cm^3

20. A sample of an ideal gas is cooled from 50.0^{o}C to 25.0^{o}C in a sealed container at constant volume. Which of the following values for the gas will decrease?

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

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

21. All of the following statements concerning the characteristics of the halogens are true EXCEPT:

(A) The first ionization energies decreases as the atomic number of the halogen increase.
(B) Fluorine is the best oxidizing agent (most reactive).
(C) Fluorine atoms have the smallest radii.
(D) Iodine liberates free bromine from a solution of bromide ion.
(E) Fluorine is the most electronegative of the halogens.

22. Molecules that have planar configurations include which of the following?

I. BCl_3
II. $CHCl_3$
III. NCl_3

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

23. $I_2\,(g) + 3\,Cl_2\,(g) \rightarrow 2\,ICl_3\,(g)$

Bond	Average Bond Energy (kJ / mole)
I – I	149
Cl – Cl	239
I – Cl	208

(A) -860 kJ
(B) -382 kJ
(C) +180 kJ
(D) +450 kJ
(E) +1248 kJ

24. The electron-dot structure (Lewis structure) for which of the following molecules would have two unshared pairs of electrons on the central atom?

(A) H_2S
(B) NH_3
(C) CH_4
(D) HCN
(E) CO_2

25. Which of the following molecules will have a dipole moment of zero?

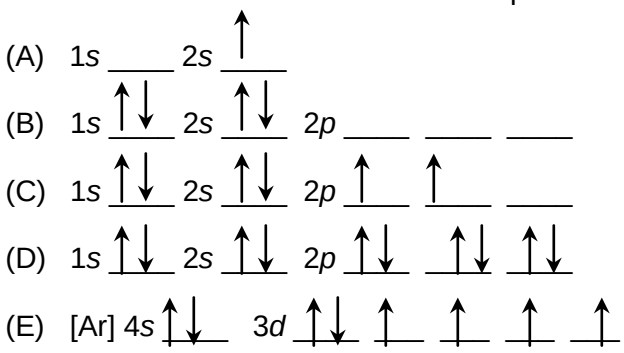
(A) C_2H_6
(B) NO
(C) SO_2
(D) HH_3
(E) H_2S

26. $\ldots\ldots Fe(OH)_2 + \ldots\ldots O_2 + \ldots\ldots H_2O \rightarrow \ldots\ldots Fe(OH)_3$

If 1 mole of O_2 oxidizes $Fe(OH)_2$ according to the reaction represented above, how many moles of $Fe(OH)_3$ can be formed?

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

Questions 27-30 refer to atoms for which the occupied atomic orbitals are shown below.



27. Represents an atom that is chemically unreactive.

28. Represents an atom in an excited state.

29. Represents an atom that has four valence electrons.

30. Represents an atom of a transition metal.

Questions 31-32 refer to the following elements.

(A) Lithium
(B) Nickel
(C) Bromine
(D) Uranium
(E) Fluorine

31. Is a gas in its standard state of 298 K.

32. Reacts with water to form a strong base.

33. What mass of Au is produced when 0.0500 mol of Au_2S_3 is reduced with excess H_2?

(A) 9.85 g (B) 19.7 g (C) 24.5 g (D) 39.4 g (E) 48.9 g

34. When a solution of sodium chloride is vaporized in a flame, the color of the flame is

(A) blue (B) yellow (C) green (D) violet (E) white

35. Types of hybridization exhibited by the C atoms in propene, CH_3CHCH_2, include which of the following?

I. sp
II. sp^2
III. sp^3

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

36. A hot-air balloon, shown above, rises.
Which of the following is the *best* explanation for this observation?

(A) The pressure on the walls of the balloon increases with increasing temperature.
(B) The difference in temperature between the air inside and outside the balloon produces convection currents.
(C) The cooler air outside the balloon pushed in on the walls of the balloon.
(D) The rate of diffusion of the cooler air is less than that of the warmer air.
(E) The density inside the balloon is less than that of the surrounding air.

37. ……$C_{10}H_{12}O_4S(s)$ + ……$O_2(g)$ → ……$CO_2(g)$ + ……$SO_2(g)$ + ……$H_2O(g)$

When the equation above is balanced and all the coefficients are reduced to their lowest whole-numbered terms, the coefficient for O_2 (*g*) is

(A) 6 (B) 7 (C) 12 (D) 14 (E) 28

38. The melting point of MgO is higher than that of NaF. Explanations for this observation include which of the following?

I. Mg^{2+} is more positively charged than Na^{1+}
II. O^{2-} is more negatively charged than F^{1-}
III. The O^{2-} ion is smaller than F^{1-} ion

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

Ionization Energies for element *X* (kJ mol^{-1})				
First	Second	Third	Fourth	Fifth
580	1,815	2,740	11,600	14,800

39. The ionization energies for the element *X* are listed in the table above. On the basis of the data, element *X* is most likely to be

(A) Na (B) Mg (C) Al (D) Si (E) P

40. Of the following molecules, which has the largest dipole moment?

(A) CO (B) CO_2 (C) O_2 (D) HF (E) F_2

41. …..LisN (*s*) + ……H_2O (*l*) → ……Li^{1+} (*aq*) + ……OH^{1-} (*aq*) + ……NH_3 (*g*)

When the equation above is balanced and all coefficients reduced to lowest whole-number terms, the coefficient for OH^{1-} (*aq*) is

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

42. A rigid metal tank contains oxygen gas. Which of the following applies to the gas in the tank when additional oxygen is added at constant temperature?

(A) The volume of the gas increases.
(B) The pressure of the gas decreases.
(C) The average speed of the gas molecules remains the same.
(D) The total number of gas molecules remains the same.
(E) The average distance between gas molecules increases.

43. In the periodic table, as the atomic number increases from 11 to 17, what happens to the atomic radius?

(A) It remains constant.
(B) It increases only.
(C) It increases, then decreases.
(D) It decreases only.
(E) It decreases, then increases.

44. Which of the following techniques is most appropriate for the recovery of solid KNO_3 from an aqueous solution of KNO_3?

(A) Paper chromatography
(B) Filtration
(C) Titration
(D) Electrolysis
(E) Evaporation to dryness

45. Which of the following is the correct interpretation of the results of Rutherford's experiments in which gold atoms were bombarded with alpha particles?

(A) Atoms have equal number of positive and negative charges.
(B) Electrons in atoms are arranged in shells.
(C) Neutrons are in the center of the atom.
(D) Neutrons and protons of atoms have nearly equal mass.
(E) The positive charge of an atom is concentrated in a small region.

46. $W(g) + X(g) \rightarrow Y(g) + Z(g)$

Gases W and X react in a closed, rigid vessel to form gases Y and Z according to the equation above. The initial pressure of W(*g*) is 1.20 atm and that of X(*g*) is 1.60 atm. No Y(*g*) or Z(*g*) is initially present. The experiment is carried out at constant temperature. What is the partial pressure of Z(*g*) when the partial pressure of W(*g*) has decreased to 1.0 atm?

(A) 0.20 atm (B) 0.40 atm (C) 1.0 atm (D) 1.2 atm (E) 1.4 atm

47. $10\ HI + 2\ KMnO_4 + 3\ H_2SO_4 \rightarrow 5\ I_2 + 2\ MnSO_4 + K_2SO_4 + 8\ H_2O$

According to the balanced equation above, how many moles of HI would be necessary to produce 2.5 mol of I_2, starting with 4.0 mol of $KMnO_4$ and 3.0 mol of H_2SO_4?

(A) 20. (B) 10. (C) 8.0 (D) 5.0 (E) 2.5

48. A yellow precipitate forms when 0.5 M NaI(*aq*) is added to a 0.5 M solution of which of the following ions?

(A) $Pb^{2+}(aq)$ (B) $Zn^{2+}(aq)$ (C) $CrO_4^{2-}(aq)$ (D) $SO_4^{2-}(aq)$ (E) $OH^{1-}(aq)$

49. $NH_4NO_3(s) \rightarrow N_2O + 2\ H_2O$

A 0.03 mol sample of NH_4NO_3 (*s*) is placed in a 1 L evacuated flask, which is then sealed and heated. The NH_4NO_3 (*s*) decomposes completely according to the balanced equation above. The total pressure in the flask measured at 400 K is closest to the following?

(A) 3 atm (B) 1 atm (C) 0.5 atm (D) 0.1 atm (E) 0.03 atm

50. $C_2H_4(g) + 3\ O_2 \rightarrow 2\ CO_2(g) + 2\ H_2O(g)$

For the reaction of ethylene represented above, ΔH is –1323 kJ. What is the value of ΔH if the combustion produced liquid water H_2O (*l*), rather than water vapor H_2O (*g*)?
(ΔH for the phase change $H_2O(g) \rightarrow H_2O(l)$ is -44 kJ/mol).

51. Equal numbers of moles of He(*g*), Ar(*g*), and Ne(*g*) are placed in a glass vessel at room temperature. If the vessel has a pinhole-sized leak, which of the following will be true regarding the relative values of the partial pressures of the gases remaining in the vessel after some of the gas mixture has effused?

(A) $P_{He} < P_{Ne} < P_{Ar}$
(B) $P_{He} < P_{Ar} < P_{Ne}$
(C) $P_{Ne} < P_{Ar} < P_{He}$
(D) $P_{Ar} < P_{He} < P_{Ne}$
(E) $P_{He} = P_{Ne} = P_{Ar}$

52. Which of the following gases deviates most from ideal behavior?

(A) SO_2 (B) Ne (C) CH_4 (D) N_2 (E) H_2

AP CHEM FALL FINAL

SECTION II PART A

Answer the following questions regarding light and its interactions with molecules, atoms, and ions.

1) The longest wavelength of light with enough energy to break the Cl-Cl bond in Cl_2 (*g*) is 495 nm.

a) Calculate the frequency, in s^{-1}, of the light

b) Calculate the energy, in J, of a photon of light

c) Calculate the minimum energy, in kJ/mol, of the Cl-Cl bond.

2) A certain line in the spectrum of atomic hydrogen is associated with the electronic in the H atom from the sixth energy level (n = 6) to the second energy level (n = 2).

(a) Indicate whether the H atom emits energy or whether it absorbs energy during the transition. Justify your answer.

(b) Calculate the wavelength, in nm, of the radiation associated with the spectral line.

(c) Account for the observation that the amount of energy associated with the same electronic transition (n = 6 to n=2) in the He^{1+} ion is greater than that associated with the corresponding transition in the H atom.

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SECTION II PART B

Solve EITHER problem 1 OR problem 2 in this part.

1. 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*).

   b) Calculate the volume of air at 30. ^oC and 1.00 atmosphere that is needed to burn completely 10.0 grams of propane. Assume that air is 21.0% O_2 by volume.

   c) The heat of combustion of propane is –2220.1 kJ/mol. Calculate the heat of formation, ΔH_f^o, of propane given that ΔH_f^o of H_2O (*l*) = -285.3 kJ/mol and ΔH_f^o of CO_2 (*g*) = -393.5 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 x K)), calculate the increase in temperature of the water.

2. A sample of dolomitic limestone containing only CaC_3 and $MgCO_3$ was analyzed.

   a) When a 0.2800 gram sample of this limestone was decomposed by heating, 75.0 milliliters of CO_2 at 750 mm Hg and 20. ^oC were evolved. How many grams of CO_2 were produced?

   b) Write equations for the decomposition of <u>both</u> carbonates described above.

   c) It was also determined that the initial sample contained 0.0448 gram of calcium. What percent of the limestone by mass was $CaCO_3$?

   d) How many grams of the magnesium-containing product were present in the sample in (a) after it had been heated?

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SECTION II PART C

Answer FIVE of the eight options in this part. (Answers to more than five options will not be scored!)

Give the formulas to show the reactants and the products in FIVE of the following chemical reactions. Each of the reactions occur in aqueous solution unless otherwise indicated. Represent substances in solutions as ions if the substance is extensively ionized. *Omit formulas for any ions or molecules that are unchanged by the reaction*. In all cases a reaction occurs. You need not balance.

Example: A strip of magnesium is added to a solution of silver nitrate.

$$Mg + Ag^{1+} \rightarrow Mg^{2+} + Ag$$

a) Solid barium carbonate is heated strongly.

b) A piece of nickel metal is immersed in a solution of copper (II) sulfate.

c) Equal volumes of equimolar solutions of disodium hydrogen phosphate and hydrochloric acid are mixed.

d) Chlorine gas in bubbled through a solution of sodium bromide.

e) Ammonia gas is bubbled into a solution of ethanoic (acetic) acid.

f) Solid ammonium carbonate is added to a saturated solution of barium hydroxide.

g) Drops of liquid dinitrogen trioxide are added to distilled water.

h) Solutions of potassium permanganate and sodium oxalate are mixed.

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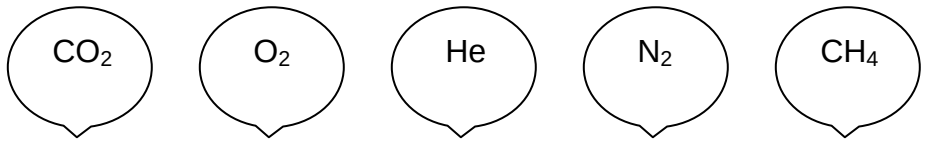
SECTION II PART D

Answer Question 1 and any **TWO** *questions from among Questions 2, 3, and 4.* Answering these questions provides an opportunity to demonstrate your ability to present your material in logical, coherent, and convincing English. Your responses will be judged on the basis of accuracy and importance of the detail cited and on the appropriateness of the descriptive material used. Specific answers are preferable to broad diffuse responses. Illustrative examples and equations may be helpful.

1.



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

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

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

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

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

SELECT TWO OF THE FOLLOWING THREE ESSAYS NUMBERED 2 THROUGH 4.
Additional essay will not be scored. If you start all three essays, be sure to cross out the one you do not want scored.

2. Explain each of the following observations using principles of atomic structure and/or bonding.

a) Potassium has a lower first ionization energy than lithium.

b) The ionic radius of N^{3-} is larger than that of O^{2-}.

c) A calcium atom is larger than a zinc atom.

d) Boron has a lower first ionization energy than beryllium.

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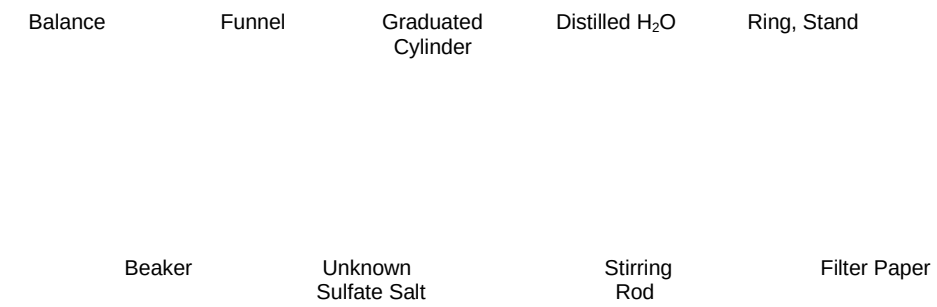
SECTION II PART D

3.



An experiment is to be performed to determine the mass percent of sulfate in an unknown soluble sulfate salt. The equipment shown above is available for the experiment. A drying oven is also available.

a) Briefly list the steps needed to carry out this experiment.

b) What experimental data need to be collected to calculate the mass percent of sulfate in the unknown.

c) List the calculations necessary to determine the mass percent sulfate in the unknown.

d) Would 0.20-molar $MgCl_2$ be an acceptable substitute for the $BaCl_2$ solution provided for this experiment? Explain.

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SECTION II PART D

4.

Graphic

Goes

Here

A student performs an experiment to determine the molar mass of an unknown gas. A small amount of pure gas is released from a pressurized container and collected in a graduated tube over water at room temperature, as shown in the diagram above. The collection tube containing gas is allowed to stand for several minutes, and its depth is adjusted until the water levels inside and outside the tubes are the same.

Assume that:

- *the gas is not appreciably soluble in water*
- *the gas collected in the graduated tube and the water are at thermal equilibrium*
- *a barometer, a thermometer, an analytical balance, and a table of the equilibrium vapor pressure of water at various temperatures are also available*.

a) Write the equation(s) needed to calculate the molar mass of the gas.

b) List the measurements that must be made in order to calculate the molar mass of the gas.

c) Explain the purpose of equalizing the water levels inside and outside the gas collection tube.

d) The student determines the molar mass of the gas to be 64 g mol^{-1}. Write the expression (set-up) for calculating the percent error in the experimental value, assuming that the unknown gas is butane (molar mass 58 g mol^{-1}). Calculations are not required.

e). If the student fails to use information from the table of the equilibrium vapor pressures of water in the calculation, the calculated value for the molar mass of the unknown gas will be smaller than the actual value. Explain.

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ANSWER KEY

1. **C**	11. **D**	21. **D**	31. **E**	41. **C**
2. **E**	12. **C**	22. **A**	32. **A**	42. **C**
3. **B**	13. **D**	23. **C**	33. **B**	43. **D**
4. **A**	14. **C**	24. **A**	34. **B**	44. **B**
5. **C**	15. **C**	25. **A**	35. **D**	45. **E**
6. **D**	16. **D**	26. **C**	36. **E** **(A?)**	46. **A**
7. **C**	17. **C**	27. **D**	37. **C**	47. **D**
8. **E**	18. **C**	28. **A**	38. **B**	48. **A**
9. **B**	19. **D**	29. **C**	39. **C**	49. **A**
10. **D**	20. **E**	30. **E**	40. **D**	50. **E**
				51. **A**
				52. **A**

SECTION II PART A

1

a) $v = \frac{c}{\lambda} \Rightarrow \frac{3.00\times10^{8}\ \cancel{m}/\cancel{s}}{4.95\times10^{-7}\ m} \Rightarrow 6.06\times10^{14}\ Hz$

b) $E = h\cdot v \Rightarrow 6.06\times10^{14}\ \cancel{Hz} \times 6.63\times10^{-34}\ J\cdot\cancel{s} \Rightarrow 4.02\times10^{-19}\ J$

c) $\frac{4.02\times10^{-19}\ J}{molecule} \times \frac{6.022\times10^{23}\ molecules}{mole} \times \frac{1kJ}{1000\ J} \Rightarrow 242\ kJ/mole$

2

a) electron falls from n = 6 to n = 2 and loses energy. Energy is emitted.

$$E_6 = \frac{-2.178\times10^{-18}}{36} J \Rightarrow -6.05\times10^{-20} J \qquad E_2 = \frac{-2.178\times10^{-18}}{4} J \Rightarrow -5.45\times10^{-19} J$$

$$\Delta E = 4.84\times10^{-19} J$$

b) $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} \Rightarrow \frac{6.63\times10^{-34}\ J\cdot s \times 3.00\times10^{8}\ m/s}{4.84\times10^{-19}\ J} \Rightarrow 4.11\times10^{-7} m = 411\ nm$

c) He^{1+} = 2 protons & 1 electron and H = 1 proton & 1 electron
so more EPE (greater nuclear charge: takes more energy to pull away the same distance)

AP CHEM FALL FINAL

ANSWER KEY

SECTION II PART A

Solve EITHER problem 1 OR problem 2 in this part.

1a) $\underset{10.0\ g}{C_3H_8(g)} + \underset{x\ mole}{5\ O_2(g)} \rightarrow 3\ CO_2(g) + 4\ H_2O(l)$

b) $$x\ mol\ O_2 = 10.0\ g\ C_3H_8\left(\frac{1 mol\ C_3H_8}{44.11\ g\ C_3H_8}\right)\left(\frac{5\ mole\ O_2}{1 mole\ C_3H_8}\right) = 1.13\ mole\ O_2$$

$$V = \frac{nRT}{P} \Rightarrow \frac{(1.13\ mol\ O_2)(0.8211\ atm \cdot L/mol \cdot K)(303\ K)}{1.00\ atm} \Rightarrow 28.2\ L\ O_2$$

$$L_{air} = \frac{L_{O_2}}{0.210} \Rightarrow \frac{28.2\ L\ O_2}{0.210} \Rightarrow 134\ L$$

c) 3(-393.5) + 4(-285.3) - X = -2220.1 kJ

-1180.5 kJ + -1141.2 kJ - X = -2220.1 kJ

X = -101.6 kJ/mole

d) $$x\ kJ = 30.0\ g\ C_3H_8\left(\frac{1 mole\ C_3H_8}{44.11\ g\ C_3H_8}\right)\left(\frac{-2220.1 kJ}{1 mole}\right) \Rightarrow -1510\ kJ$$

$$Q = m \cdot C_p \cdot \Delta T$$

$$\Delta T = \frac{Q}{m \cdot C_p} \Rightarrow \frac{-1510\ kJ}{(3\ kg)(4.18\ J/g \cdot K)} \Rightarrow 45.2^{\circ}C$$

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ANSWER KEY

SECTION II PART B

Solve EITHER problem 1 OR problem 2 in this part.

2a) 2800 g sample limestone

$$n = \frac{PV}{RT} \Rightarrow \frac{\left(\frac{750\ mm\ Hg}{760\ mm\ Hg}\right)(0.0750\ L)}{(0.0821 L \cdot atm/mol \cdot K)(293\ K)} \Rightarrow 3.08 \times 10^{3}\ mol$$

V = 0.750 L CO_2
P = 750 mm Hg x (1 atm/760 mm Hg)
T = 293 K
X = ? g CO_2

$$x\ g\ CO_2 = 3.08 \times 10^{3} mole\ CO_2 \left(\frac{44.01\ g\ CO_2}{1\ mole\ CO_2}\right) \Rightarrow 0.1354\ g\ CO_2$$

b) $CaCO_3 \rightarrow CaO + CO_2$
$MgCO_3 \rightarrow MgO + CO_2$

c) $$x\ mol\ CaO = 0.0448\ g\ Ca \left(\frac{1\ mole\ Ca}{40.08\ g\ Ca}\right)\left(\frac{1\ mole\ CaO}{1\ mole\ Ca}\right)\left(\frac{56.08\ g\ CaO}{1\ mole\ CaO}\right) \Rightarrow 0.0627\ g$$

$CaO + CO_2 \rightarrow CaCO_3$

$$x\ mol\ CaCO_3 = 0.0627\ g\ CaO \left(\frac{1 mole\ CaO}{56.08\ g\ CaO}\right)\left(\frac{1 mole\ CaCO_3}{1 mole\ CaO}\right)\left(\frac{100.09\ g\ CaCO_3}{1\ mole\ CaCO_3}\right) \Rightarrow 0.1119\ g\ CaCO_3$$

$$\% = \frac{actual}{theoretical} \times 100 \Rightarrow \frac{0.1119\ g\ CaCO_3}{0.2800\ g\ CaCO_3} \times 100\% \Rightarrow 39.96\ \%\ CaCO_3$$

d)

0.2800	g	SAMPLE
− 0.1354	g	CO_2
− 0.0627	g	CaO
0.0819	g	MgO

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ANSWER KEY

SECTION II PART C

a) Solid barium carbonate is heated strongly.

$$BaCO_3 \xrightarrow{\Delta} BaO + CO_2$$

b) A piece of nickel metal is immersed in a solution of copper (II) sulfate.

$$Ni + Cu^{2+} \rightarrow Ni^{2+} + Cu$$

c) Equal volumes of equimolar solutions of disodium hydrogen phosphate and hydrochloric acid are mixed.

$$HPO_4^{2-} + H^{1+} \rightarrow H_2PO_4^{1-}$$

d) Chlorine gas in bubbled through a solution of sodium bromide.

$$Cl_2 + Br^{1-} \rightarrow Cl^{1-} + Br_2$$

e) Ammonia gas is bubbled into a solution of ethanoic (acetic) acid.

$$NH_3 + H^{1+} \rightarrow NH_4^{1+}$$

f) Solid ammonium carbonate is added to a saturated solution of barium hydroxide.

$$CO_3^{2-} + Ba^{2+} \rightarrow BaCO_3$$

g) Drops of liquid dinitrogen trioxide are added to distilled water.

$$N_2O_3 + H_2O \rightarrow H^{1+} + NO_2^{1-}$$

h) Solutions of potassium permanganate and sodium oxalate are mixed.

$$MnO_4 + C_2O_4 \rightarrow Mn^{2+} + CO_2 + H_2O \text{ ?? (redox)}$$

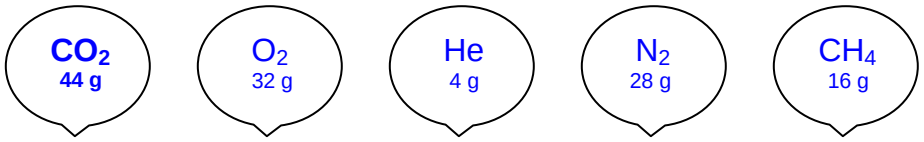
AP CHEM FALL FINAL

ANSWER KEY

SECTION II PART D

Answer Question 1 and any **TWO** *questions from among Questions 2, 3, and 4.* Answering these questions provides an opportunity to demonstrate your ability to present your material in logical, coherent, and convincing English. Your responses will be judged on the basis of accuracy and importance of the detail cited and on the appropriateness of the descriptive material used. Specific answers are preferable to broad diffuse responses. Illustrative examples and equations may be helpful.

1.



Represented above are five identical balloons

1a) **same conditions = same # of moles (Avagadro's hypothesis)**
CO_2 has most mass since each balloon has same number of moles.

b) **All have same kinetic energy because all are same temperature (25°C). Avg. KE = temperature**

c) **CO_2 has largest molar mass. Increase molar mass has largest deviation.**
Has 4 non-bonding electron pairs.
CH_4 would be high due to its tetrahedral geometry; but not as large as CO_2

d) **He will be the smallest Graham's law of effusion. Lower molar mass the faster effusion.**

$$\frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}}$$

2a) **Potassium (K) has a lower first ionization due to *shielding* (or screening) by n = 1, 2, 3.**
Lithium (Li) is only shielded by n = 1.

b) **N^{3-} is larger than O^{2-}. Both have same # of electrons (are *isoelectronic*); but oxygen ion has 1 more proton (greater nuclear charge). Additional proton of O^{2-} produces greater *coulombic attraction* (higher pull).**

c) **Ca is larger than Zn $Zn_{eff} > Ca_{eff}$ Both in same period: size decreases across period.**

d) **Be has higher 1st ionization energy than B.**

Since Be has a filled orbital (when it loses an electron) $2s^2 2p^1 \rightarrow 2s^2 + e$ (stable)
To remove an electron from B … $2s^2 \rightarrow 2s^1 + e$ (unstable)

(removes an electron from a full, stable 2s orbital to form an unpaired orbital.)

AP CHEM FALL FINAL

ANSWER KEY

SECTION II PART D

3a)

- **Place beaker on balance and record mass.**
- **Place an unknown salt in beaker and record mass.**
- **Dissolve salt in water (an ionic "salt" is solid, so will dissolve in *polar* water)**
- **Place an measured aliquot or 0.20 *M* $BaCl_2$ in graduated cylinder and record volume**
  Pour into beaker with unknown sulfate.
  Repeat several times to ensure an *excess*.
- **Stir solution in beaker.**
- **Filter out the precipitate ($BaSO_4$) (use a filter paper in funnel)**
- **Wash solid with distilled water**
- **Dry solid**
- **Record mass of dry solid.**

3b)

- **Mass of unknown sulfate**
- **mass of precipitate, $BaSO_4$**
  volume of 0.20 *M* $BaCl_2$ (not needed = excess reagent)

3c)

Mass of $BaSO_4$. Calculate the mass of SO_4^{2-}.
Original mass of salt is known.

$$\%\ \text{sulfate} = \frac{\text{mass of sulfate}}{\text{mass of unknown}} \times 100$$

3d)

No, $MgSO_4$ is soluble in water and wouldn't precipitate out.
$MgCl_2$ would not be an acceptable substitute.

sulfate salt + $BaCl_2$ → $BaSO_4$ (*ppt*) + soluble chloride

sulfate salt + $MgCl_2$ → $MgSO_4$ (*aq*) + soluble chloride

AP CHEM FALL FINAL

ANSWER KEY

SECTION II PART D

4a) $PV = nRT \Rightarrow n = \frac{PV}{RT}$ $g_{\text{mass cylinder before}} - g_{\text{mass cylinder after}}$

M = g/n $P_T = P_g + P_{water}$

4b) **mass cylinder before**
mass cylinder after
temperature
pressure
volume

4c) **When water levels are the same then gas pressure = atmospheric pressure.**
If too far down, measurement will be low.
If not far enough down, measurement will be high.

4d) $\%\,\text{Error} = \frac{|\text{actual} - \text{experimental}|}{\text{actual}} \times 100 \Rightarrow \frac{|58 - 64}{58} \times 100\,\% \Rightarrow$

4e) **Since** $P_T = P_g + P_{water}$ **Your "P_T" value will be too high.**

$n = \frac{PV}{RT}$ **High "P" value means high "n" value**

$M = \frac{g}{n}$ **So a high "n" means a low "M" (molar mass)**