
Unless stated otherwise: (1) electromagnetic radiation is traveling in a vacuum, (2) solutions are aqueous, (3) temperature is 25 °C, (4) pressure is 1 atm, and (5) substances are in their standard state.

Questions 1 – 15 cover Exam I material

1. A substance that **cannot** be chemically decomposed into simpler substances is

- | | |
|---------------------------|----------------|
| A. a homogeneous mixture. | C. an element. |
| B. a compound. | D. a nonmetal. |
-

2. Which equation illustrates a **physical change**?

- A. $\text{H}_2\text{O}(g) \rightarrow \text{H}_2\text{O}(l)$
 - B. $\text{C}_3\text{H}_8(g) + 5 \text{O}_2(g) \rightarrow 3 \text{CO}_2(g) + 4 \text{H}_2\text{O}(g)$
 - C. $\text{HCl}(aq) + \text{NaOH}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l)$
 - D. $2 \text{H}_2\text{O}(l) \rightarrow 2 \text{H}_2(g) + \text{O}_2(g)$
-

3. Which of the following is **not** a form of energy?

- | | |
|--------------|------------|
| A. kinetic | C. thermal |
| B. potential | D. motive |
-

4. How many **kilograms** are in 34.7 micrograms?

- | | |
|-------------------------------------|-------------------------------------|
| A. $3.47 \times 10^{50} \text{ kg}$ | C. $3.47 \times 10^{-3} \text{ kg}$ |
| B. $3.47 \times 10^{-5} \text{ kg}$ | D. $3.47 \times 10^{-8} \text{ kg}$ |
-

5. Gasoline costs 1.399 CAD (Canadian dollars) per liter in Toronto. If you purchase 12.00 gallons of gasoline, how much will your credit card be charged? (1 gallon = 3.7854 L)

A. 16.79 CAD

C. 63.55 CAD

B. 67.15 CAD

D. 46.88 CAD

6. What is the result of the following calculation? Use the correct number of **significant figures**.

$$(106.3 \times 104.5)^2 \div 98.1 + 9.45 \times 10^6 =$$

A. 1.2×10^6

C. 8.67×10^6

B. 1.07×10^7

D. 5.309×10^8

7. The statement that “in a chemical reaction, matter is neither created or destroyed” is an expression of

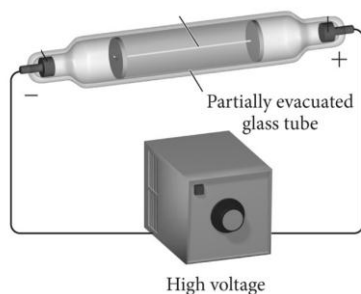
A. the Law of Conservation of Mass.

C. the Law of Definite Proportions.

B. the First Law of Thermodynamics.

D. Modern Atomic Theory.

-
8. The figure below depicts a cathode ray tube. Which **subatomic particles** were discovered by observing changes in the path of cathode rays in applied magnetic and electric fields?



- A. neutrons
B. gluons
C. protons
D. electrons
-
9. Which of the following contains 17 protons, 18 neutrons, and 18 electrons?

- A. ^{36}Ar
B. $^{35}\text{Cl}^-$
C. $^{36}\text{Ar}^+$
D. ^{35}Cl

-
10. Naturally occurring boron has two stable isotopes and an atomic mass of 10.81 amu. If ^{10}B (10.013 amu) is 19.9% of natural boron, what is the **atomic mass** of the other isotope?

- A. 10.81 amu
B. 11.10 amu
C. 11.01 amu
D. 11.30 amu
-

11. Which of the following contains the **greatest number of atoms**?

A. 10.0 g of Ar

C. 10.0 g of He

B. 25.0 g of Kr

D. 50.0 g of U

12. How many **atoms** are in 17.92 grams of ethanol ($\text{CH}_3\text{CH}_2\text{OH}$, 46.07 g/mol)?

A. 6.108×10^{23} atoms

C. 4.74×10^8 atoms

B. 2.108×10^{24} atoms

D. 3.275×10^{26} atoms

13. Which of the following is an **ionic** compound?

A. MgF_2

C. SeBr_2

B. NO_2

D. CF_4

14. What is the chemical name of MoO_3 ?

A. molybdenum trioxide

C. molybdenum oxide

B. monomolybdenum oxide

D. molybdenum (VI) oxide

15. What is the **mass** of 6.89×10^{25} molecules of CO_2 ? (molar mass of $\text{CO}_2 = 44.01 \text{ g/mol}$)

A. 3.03 kg

C. 3.85 kg

B. 6.39 kg

D. 5.04 kg

Questions 16 – 30 cover Exam II material

16. How many **grams of selenium** are in 18.65 grams of selenium dioxide?

A. 5.96 g

C. 13.27 g

B. 7.76 g

D. 12.26 g

17. What is the **empirical formula** of a compound that is 49.48% carbon, 5.19% hydrogen, 28.85% nitrogen, and 16.48% oxygen?

A. $\text{C}_8\text{H}_{10}\text{N}_2\text{O}$

C. $\text{C}_4\text{H}_5\text{N}_2\text{O}$

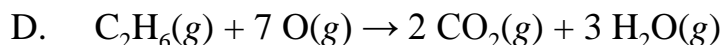
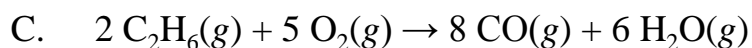
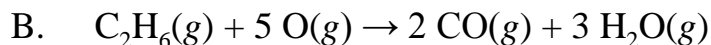
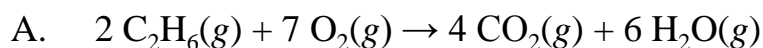
B. $\text{C}_5\text{H}_4\text{N}_2\text{O}_2$

D. CHNO

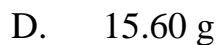
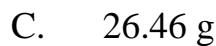
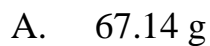
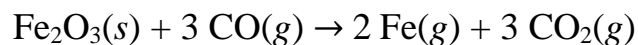
18. What is the **molecular formula** of a compound with a molar mass of 296.24 g/mol and an empirical formula of $C_2H_4NO_2$?



19. Which of the following is the **balanced equation** for the combustion of ethane in oxygen?



20. Consider the following balanced reaction equation. How many **grams of iron** are formed when 22.3 g of iron(III) oxide are allowed to react with 44.3 g of carbon monoxide?



24. What is the **oxidation number** of vanadium in VO_2 ?

A. +1

C. +2

B. +3

D. +4

25. What **mass of NO_2** gas is contained in a 13.0-L tank at 4.58 atm and 385 K?

A. 24.4 g

C. 69.2 g

B. 53.1 g

D. 86.7 g

26. A 10.0-L gaseous mixture contains oxygen, nitrogen, neon, and helium at 0°C . The partial pressures of the gases are $P_{\text{O}_2} = 0.60$ atm, $P_{\text{N}_2} = 0.50$ atm, $P_{\text{Ne}} = 0.10$ atm and $P_{\text{He}} = 0.20$ atm. How many **grams** of nitrogen are in the mixture?

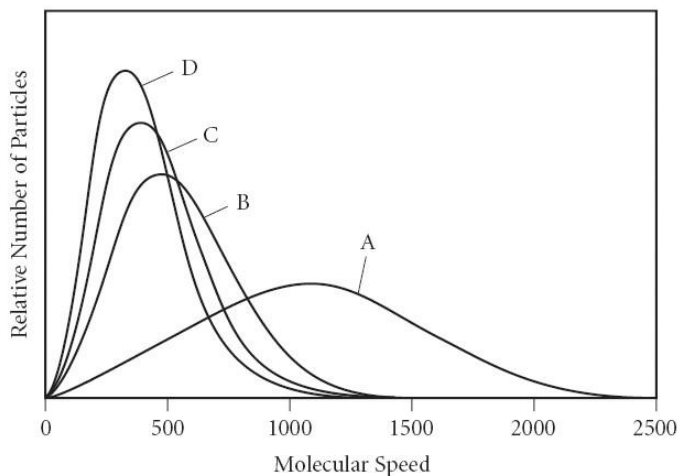
A. 0.33 g

C. 6.3 g

B. 0.75 g

D. 7.1 g

27. The gases Ar, N₂, NH₃, and N₂O₄ are compared in the plot below. If all of these gases are at the same temperature, which of these curves represents **nitrogen**?



A. A

C. C

B. B

D. D

28. An ideal gas occupies 3.8 liters at a pressure of 0.70 atm. If the volume of the gas is **halved**, what is the pressure? The temperature and the amount of gas are held constant.

A. 0.35 atm

C. 2.2 atm

B. 1.4 atm

D. 4.4 atm

29. The term “mean free path” describes

- A. the distance between particles in an ideal gas.
- B. the route that a gas molecule travels when effusing through a small hole into a vacuum.
- C. the average distance that a gas particle travels between collisions with other gas particles.
- D. the time between particle collisions in a real gas.

30. The greatest **deviations from ideal gas behavior** are observed under what conditions?

- A. high temperature and high pressure
- B. low temperature and low pressure
- C. low temperature and high pressure
- D. Gases always behave ideally.

Questions 31 – 45 cover Exam III material

31. Which energy conversion is **not** correct?

- A. $4.184 \text{ J} = 1 \text{ calorie}$
- B. $1 \text{ calorie} = 1000 \text{ Calories}$
- C. $1 \text{ L}\cdot\text{atm} = 101.3 \text{ J}$
- D. $1 \text{ Calorie} = 4.184 \text{ kJ}$

32. An athlete sprains her ankle and applies an ice pack to reduce swelling. If the **ice pack is the system**, what are the magnitudes of ΔE_{system} and $\Delta E_{\text{surroundings}}$?

- A. $\Delta E_{\text{system}} > 0$; $\Delta E_{\text{surroundings}} < 0$
 - B. $\Delta E_{\text{system}} > 0$; $\Delta E_{\text{surroundings}} = 0$
 - C. $\Delta E_{\text{system}} < 0$; $\Delta E_{\text{surroundings}} = 0$
 - D. $\Delta E_{\text{system}} < 0$; $\Delta E_{\text{surroundings}} > 0$
-

33. Which of the following would show the **smallest temperature change** upon gaining 200.0 J of heat?

A. 50.0 g Cu, $C_s(\text{Cu}) = 0.385 \text{ J/g}\cdot^\circ\text{C}$

C. 50.0 g Al, $C_s(\text{Al}) = 0.903 \text{ J/g}\cdot^\circ\text{C}$

B. 25.0 g Au, $C_s(\text{Au}) = 0.128 \text{ J/g}\cdot^\circ\text{C}$

D. 25.0 g Ag, $C_s(\text{Ag}) = 0.235 \text{ J/g}\cdot^\circ\text{C}$

34. If a 376 g gold nugget at an initial temperature of 398 K loses 4.85 kJ of heat when placed in glass of water, what is the **final temperature** of the gold nugget?

$C_s(\text{Au}) = 0.128 \text{ J/g}\cdot^\circ\text{C}$; $C_s(\text{water}) = 4.18 \text{ J/g}\cdot^\circ\text{C}$

A. 398 K

C. 187 K

B. 133 K

D. 297 K

35. What is the **change in internal energy** (ΔE) of a system that gives off 25.0 kJ of heat and changes volume from 12.00 L to 6.00 L at 1.50 atm pressure? $101.3 \text{ J} = 1 \text{ L}\cdot\text{atm}$

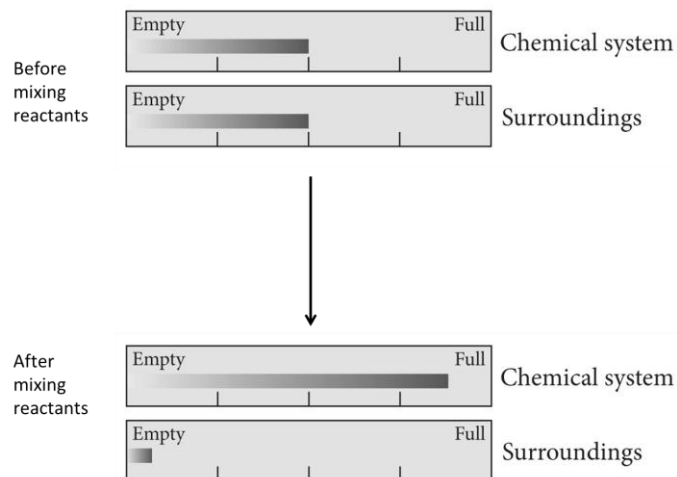
A. 16.0 kJ

C. -24.1 kJ

B. 25.0 kJ

D. -25.9 kJ

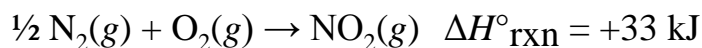
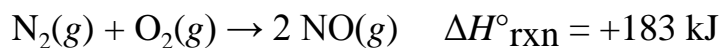
36. Consider the following diagram:



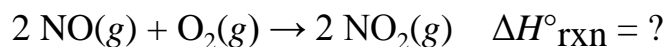
If the gauges represent enthalpy values like a fuel gauge in an automobile, which of the following statements **best** explains the diagram?

- A. The reaction is endothermic and the system absorbs energy from the reactants.
- B. The reaction is endothermic and the system absorbs energy from the surroundings.
- C. The reaction is exothermic and the system absorbs energy from the surroundings.
- D. The reaction is exothermic and the system absorbs energy from the reactants.

37. From the standard enthalpies of reaction given below,

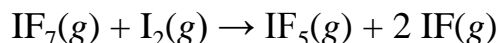


what is $\Delta H^\circ_{\text{rxn}}$ for the following reaction?



- A. -117 kJ
 - B. -151 kJ
 - C. $+115 \text{ kJ}$
 - D. $+238 \text{ kJ}$
-

38. What is ΔH_{rxn} for the following reaction?



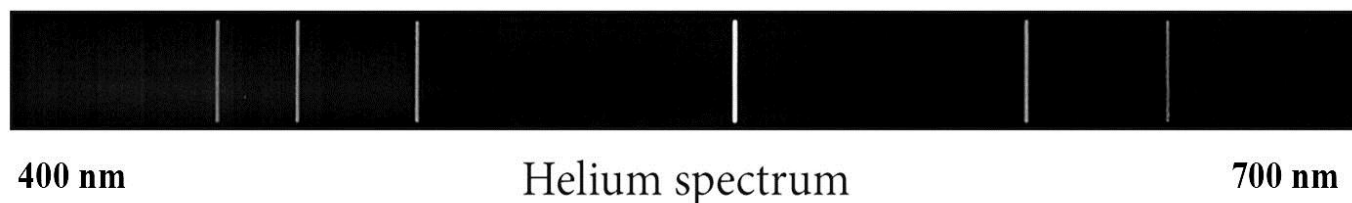
<u>Compound</u>	<u>ΔH°_f (kJ/mol)</u>
IF ₇	-941
IF ₅	-840
IF ₁	-95

- A. 101 kJ
B. -190 kJ
C. -146 kJ
D. -89 kJ

39. Which of the following colors of visible light has the **highest frequency**?

- A. green
B. red
C. blue
D. yellow

40. Which is a **correct** statement about the atomic emission spectrum of helium shown below?



- A. The bright lines in the atomic emission spectrum show that helium can absorb and emit all frequencies of electromagnetic radiation.
- B. The bright lines in the atomic emission spectrum result from the quantized emission of photons.
- C. The dark regions in the atomic emission spectrum of helium are the result of x-ray radiation.
- D. The atomic emission spectrum of helium is identical to those of all other noble gases.
-

41. Which of the following transitions (in a hydrogen atom) represents **emission of the longest wavelength photon**?

A. $n = 4$ to $n = 2$

C. $n = 3$ to $n = 4$

B. $n = 3$ to $n = 1$

D. $n = 5$ to $n = 4$

42. Which of the following sets of quantum numbers describes an **f orbital**?

A. $n = 2, l = 1, m_l = -1, m_s = +1/2$

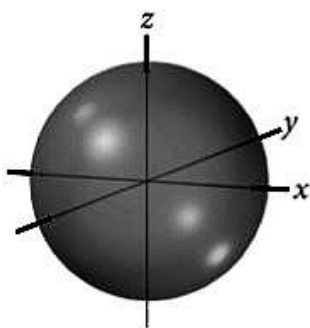
C. $n = 4, l = 2, m_l = +1, m_s = -1/2$

B. $n = 4, l = 3, m_l = +1, m_s = +1/2$

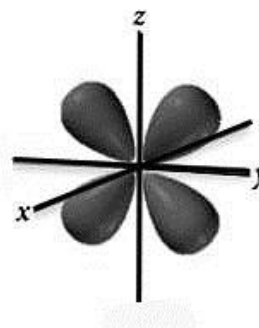
D. $n = 5, l = 0, m_l = 0, m_s = -1/2$

43. Which of the following atomic orbital shapes could be found in the **$n = 3$ shell** of an atom?

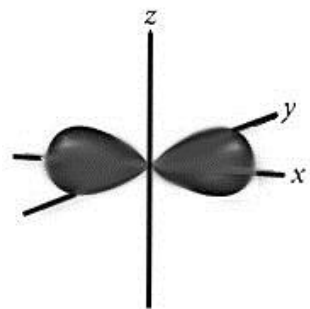
Q.



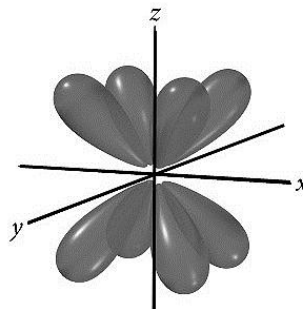
S.



R.



T.



A. Only Q, R, and S

C. Q, R, S, and T

B. Only Q and R

D. Only R and S

44. Which of the following sets of quantum numbers **contains an error**?

A. $n = 5, l = 0, m_l = 0, m_s = -\frac{1}{2}$

C. $n = 2, l = 1, m_l = 0, m_s = -\frac{1}{2}$

B. $n = 4, l = 1, m_l = 0, m_s = -\frac{1}{2}$

D. $n = 5, l = 0, m_l = +1, m_s = -\frac{1}{2}$

45. What is the **maximum number of *f* orbitals** in a shell of atomic electrons?

A. 3

C. 7

B. 5

D. 9

Questions 46 – 60 cover material after Exam III

46. Which of the following orbital diagrams describes the valence electron configuration of a **fluorine atom**?



2s

2p

2s

2p



2s

2p

3s

3p

47. Which of the following statements is **correct**?

- A. An atomic orbital that penetrates into the region occupied by core electrons is less shielded from the nuclear charge than an orbital that does not penetrate and therefore has a lower energy.
- B. Electron penetration and shielding have no effect on the radii of atoms.
- C. An atomic orbital that penetrates into the region occupied by core electrons is more shielded from the nuclear charge than an orbital that does not penetrate and therefore has a lower energy.
- D. Electron penetration and shielding have no effect on the radii of ions.

48. What is the **electron configuration** of Co^{2+} ?

- A. $[\text{Ar}] 3d^7$
- B. $[\text{Ar}] 3d^5$
- C. $[\text{Ar}]4s^23d^9$
- D. $[\text{Ar}]4s^23d^5$

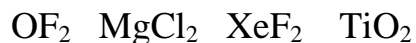
49. Of the following, which atom has the **smallest** atomic radius?

- A. K
- B. As
- C. Rb
- D. Sb

50. Which of the following elements has the **highest second** ionization energy?

- A. sodium
 - B. calcium
 - C. magnesium
 - D. aluminum
-

51. Of the following compounds, which exhibit **covalent** bonding?



- A. All exhibit strong covalent bonding. C. OF₂ and XeF₂
B. TiO₂ and MgCl₂ D. XeF₂ and TiO₂

52. Which of the following reactions has an enthalpy change that is also a **lattice energy** ($\Delta H_{\text{lattice}}$)?

- A. $\text{Li}_2\text{O}(s) \rightarrow 2 \text{Li}^+(aq) + \text{O}^{2-}(aq)$ C. $\text{Li}(s) + \frac{1}{2} \text{O}_2(g) \rightarrow \text{Li}_2\text{O}(s)$
B. $2 \text{Li}^+(g) + \text{O}^{2-}(g) \rightarrow \text{Li}_2\text{O}(s)$ D. $\text{LiOH}(aq) + \text{HCl}(aq) \rightarrow \text{H}_2\text{O}(l) + \text{LiCl}(aq)$

53. Which of the following is the **best Lewis structure** for the PO₄³⁻ anion?

- A. $\left[\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\ | \\ \text{:}\ddot{\text{O}}\text{---P---}\ddot{\text{O}}\text{:} \\ | \\ \text{:}\ddot{\text{O}}\text{:} \end{array} \right]^{3-}$ C. $\left[\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\ | \\ \text{:}\text{O}=\text{P}=\text{O}\text{:} \\ | \\ \text{:}\ddot{\text{O}}\text{:} \end{array} \right]^{3-}$
B. $\left[\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\ | \\ \text{:}\ddot{\text{O}}\text{---P---}\ddot{\text{O}}\text{:} \\ | \\ \text{:}\ddot{\text{O}}\text{:} \end{array} \right]^{3-}$ D. $\left[\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\ | \\ \text{:}\ddot{\text{O}}\text{---P}=\ddot{\text{O}}\text{:} \\ | \\ \text{:}\ddot{\text{O}}\text{:} \end{array} \right]^{3-}$
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54. Which of the following bonds is the **most** polar?

A. C–S bond

C. C–N bond

B. C–O bond

D. C–H bond

55. For the best Lewis structure of the free radical, NO_2 , what is the **formal charge** on the nitrogen atom?

A. 0

C. –1

B. +1

D. +2

56. Which of the following bonds is the **shortest**?

A. O–H bond

C. S–H bond

B. C–H bond

D. Se–H bond

57. What are the approximate **bond angles** in a CF_4 molecule?

A. 90°

C. 109.5°

B. 104.5°

D. 120°

Answer Key:

1. C
2. A
3. D
4. D
5. C
6. B
7. A
8. D
9. B
10. C
11. C
12. B
13. A
14. D
15. D
16. C
17. C
18. A
19. A
20. D
21. D
22. D
23. A
24. D
25. D
26. C
27. B
28. B
29. C
30. C
31. B
32. A
33. C
34. D
35. C
36. B
37. A
38. D
39. C

- 40. B
- 41. D
- 42. B
- 43. A
- 44. D
- 45. C
- 46. A
- 47. A
- 48. A
- 49. B
- 50. A
- 51. C
- 52. B
- 53. A
- 54. B
- 55. B
- 56. A
- 57. C
- 58. B
- 59. D
- 60. B