

Final Exam Practice Questions for General Chemistry

NOTICE TO ALL STUDENTS READING THIS MATERIAL:

These exact questions will not appear on your exam.

These example questions are provided to you help you review the material and become familiar with the TYPES of questions that are generally presented on the final exam. This is not a complete list of the ideas, concepts, principles, or questions covered in the general chemistry class. Be aware that there are many other questions and ideas that may not be covered in this list. This list does not indicate the proportion of questions from a specific chapter that will appear on the final exam. All chapters covered during the semester will be tested on the final exam. **An answer key will be provided at a later date.**

There is only one correct answer to each question. The best strategy is to arrive at your own answer to a question before looking at the choices. Otherwise, you may be misled by a plausible, but incorrect, response

1. All of the following are true except:
- An ion has a positive or negative charge.
 - Metals tend to form positive ions.
 - Ions are formed by adding electrons to a neutral atom.
 - Ions are formed by changing the number of neutrons in an atom's nucleus.
 - Ions are formed by removing electrons from a neutral atom.
2. Which one of the following statements about atomic structure is false?
- The electrons occupy a very large volume compared to the nucleus.
 - Almost all of the mass of the atom is concentrated in the nucleus.
 - The number of protons and neutrons is always equal for all atoms of an element.
 - Electrons are in quantized energy levels.
 - The protons and neutrons in the nucleus are very tightly packed.
3. What is the electron configuration for the most stable ion of the element magnesium, ${}_{12}\text{Mg}^+$?
- $1s^2 2s^2 2p^6 3s^2 3p^2$
 - $1s^2 2s^2 2p^6 3s^1$
 - $1s^2 2s^2 2p^6 3s^2 3p^6$
 - $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$
 - $1s^2 2s^2 2p^6$
4. Passing an electric current through a certain substance produces oxygen and sulfur. This substance cannot be a(n)
- pure substance
 - Compound
 - Mixture
 - Element
 - It could be any of the above.
5. Which one of the following is an extensive property?
- freezing point
 - Density
 - Mass
 - boiling point
 - temperature
6. What is the volume of a 12.2 g piece of metal with a density of 9.43 g/cm^3 ?
- 12.2 cm^3
 - 1.29 cm^3
 - 0.773 cm^3
 - 115 cm^3
 - 9.43 cm^3

7. Which one of the following is a nonmetal?

- a) ${}_{76}^{190}\text{Os}$
- b) ${}_{77}^{191}\text{Ir}$
- c) ${}_{74}^{184}\text{W}$
- d) ${}_{38}^{88}\text{Sr}$
- e) ${}_{35}^{75}\text{Br}$

8. Which of the following is most likely to be an ionic compound?

- a) NF_3
- b) Na_2O
- c) CO_2
- d) N_2
- e) CH_4

9. Use the following information to identify the atom or ion: 8 protons, 8 neutrons, and 10 electrons.

- a) S^{2+}
- b) O^{2-}
- c) O^{2+}
- d) S^{2-}
- e) Ne

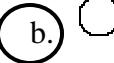
10. Calculate the wavelength of the radiation that has an energy of 3.6×10^{-17} joules.

- a) $1.8 \times 10^8 \text{ m}$
- b) 5.5 m
- c) 5.5 nm
- d) $5.5 \times 10^{16} \text{ m}$
- e) $2.3 \times 10^{-50} \text{ m}$

11. Which one of the following electron transitions in a hydrogen atom results in the greatest release of energy from the hydrogen atom?

- a) $n = 3$ to $n = 4$
- b) $n = 6$ to $n = 4$
- c) $n = 1$ to $n = 3$
- d) $n = 7$ to $n = 5$
- e) Transitions c and d result equally in the greatest release

12. Which sketch represents an orbital with the quantum numbers $n = 3$, $l = 0$, $m_l = 0$?

- a. 
- b. 
- c. 
- d. 
- e. 

13. An electron in which one of the following subshells experiences the greatest effective nuclear charge in a many-electron atom?

- a) 4f
- b) 4p
- c) 4d
- d) 4s
- e) They all experience the same effective nuclear charge.

14. Which form of electromagnetic radiation has the greatest energy?

- a) radio waves, approximately 10 m
- b) infrared radiation, approximately 10 μm
- c) UV radiation, approximately 200 nm
- d) Microwaves, approximately 10 mm
- e) x-rays, approximately 100 pm

15. The ground state electron configuration of Nickel ($_{28}\text{Ni}$) is given by

- a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
- b) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
- c) $[\text{Kr}] 5s^2 4d^6$
- d) $1s^2 2s^2 3s^2 3p^6 3d^8$
- e) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1 4p^3$

16. In an atom, how many electrons can have the quantum number designations $n=3$, $m_l=0$, $m_s=1/2$?

- a) 5
- b) 3
- c) 1
- d) 0
- e) 2

17. A sugar cube was heated until it melted completely. The heat was then increased, and the sugar decomposed into a black solid mass. The changes associated with this process are:

- a) A physical change for melting and a physical change for the decomposition.
- b) A chemical change for the melting and a chemical change for the decomposition.
- c) No change for the melting and a chemical change for the decomposition.
- d) A chemical change for the melting and a physical change for the decomposition.
- e) A physical change for the melting and a chemical change for the decomposition.

18. What is the wavelength of an electron that is moving at a velocity $3.61 \times 10^3 \text{ m/s}$?

- a) 560 nm
- b) 201 nm
- c) $1.83 \times 10^{-37} \text{ m}$
- d) 450 nm
- e) 0.201 nm

19. What is the frequency of the radiation emitted when an electron decays from the $n = 6$ to the $n = 1$ energy level?

- a) $3.30 \times 10^{15} \text{ Hz}$

- b) $9.17 \times 10^{13} \text{ Hz}$
 c) $3.20 \times 10^{15} \text{ Hz}$
d) $2.12 \times 10^{-18} \text{ Hz}$
e) $6.17 \times 10^2 \text{ Hz}$

20. Which one of the following should be the most similar in chemical properties to strontium, $^{87}_{38}Sr$?

- a) $^{87}_{39}Y$
 b) $^{40}_{20}Ca$
c) $^{87}_{37}Rb$
d) $^{223}_{87}Fr$
e) $^{38}_{14}Si$

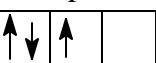
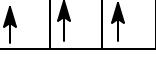
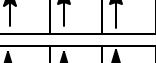
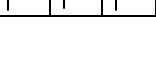
21. Which one of the following molecular formulas is also an empirical formula?

- a) $C_6H_6O_2$
 b) C_2H_6SO
c) H_2O_2
d) $H_2P_4O_6$
e) None of the above. Only ionic compounds have empirical formulas.

22. What is the formula of the ionic compound formed between strontium (Sr) and nitrogen (N)?

- a) SrN
 b) Sr_3N_2
c) Sr_2N_3
d) SrN_2
e) SrN_3

23. Which one of the following is the correct orbital diagram for ground state nitrogen (${}_7\text{N}$)?

- | | 1s | 2s | 2p |
|----|---|---|---|
| a) |  |  |  |
| b) |  |  |  |
| c) |  |  |  |
| d) |  |  |  |
| e) | None of the above | | |

24. Which of the following statements about quantum theory is incorrect?

- a) Electrons reside only in quantized energy levels.
- b) When filling orbitals with the same n and l quantum numbers, two electrons will fill the same m_l before filling a new m_l .
- c) Lower energy orbitals are filled with electrons before higher energy orbitals.
- d) No two electrons can have the same four quantum numbers in the same atom.
- e) Valence electrons are in higher energy quantum levels than inner shell (core) electrons.

25. Which one of the following combinations of quantum numbers does not represent a permissible solution of the Schroedinger equation? i.e., which combination of quantum numbers is not allowed?

- | | n | l | m_l | m_s |
|----|---|---|-------|----------------|
| a) | 8 | 2 | 2 | $\frac{1}{2}$ |
| b) | 9 | 8 | -4 | $\frac{1}{2}$ |
| c) | 6 | 6 | -1 | $\frac{1}{2}$ |
| d) | 6 | 5 | -5 | $-\frac{1}{2}$ |
| e) | 3 | 2 | 1 | $-\frac{1}{2}$ |

26. Which of the following has 2 unpaired electrons?

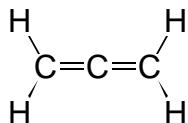
- a) As
- b) P
- c) S^{-2}
- d) Ge^{+2}
- e) Si

27. Which one of the following is the highest temperature?

- a) 38°C
- b) 96°F
- c) 302 K
- d) Temperature a = temperature c. Both are higher than temperature b.

- e) Temperature b = temperature c. Both are higher than temperature a.
28. Many classical experiments have given us indirect evidence of the nature of the atom. Which of the experiments listed below did not give the result described?
- a) The line spectrum of the hydrogen atom implied that the electronic energies are quantized.
 - b) Millikan's oil drop experiment provided a value for the charge on the electron.
 - c) The electric discharge (cathode ray) tube proved that electrons have a negative charge.
 - d) The Rutherford experiment proved the Thomson "plum-pudding" model of the atom to be essentially correct.
 - e) Rutherford and Becquerel revealed that there are three types of radiation.
29. Which of the following are incorrectly paired?
- a) Na, alkali metal
 - b) Mg, alkaline earth metal
 - c) Br, halogen
 - d) Ar, noble gas
 - e) Sn, lanthanide
1. Which of the following elements has the largest atomic radius?
- a) Si
 - b) O
 - c) Be
 - d) C
 - e) Mg
2. Which of the following elements has the greatest (most negative) electron affinity?
- a) Ne
 - b) O
 - c) C
 - d) Be
 - e) Kr
3. Which of the following is/are the best Lewis structure(s) for SO_2 based on satisfying the octet rule for all three atoms (ignore formal charge criteria)?
- a) $\ddot{\text{O}}=\text{S}=\ddot{\text{O}}$
 - b) $\ddot{\text{O}}=\text{S}=\ddot{\text{O}} \leftrightarrow :\ddot{\text{O}}-\ddot{\text{S}}-\ddot{\text{O}}:$
 - c) $:\ddot{\text{O}}-\ddot{\text{S}}=\ddot{\text{O}}$
 - d) $:\ddot{\text{O}}-\ddot{\text{S}}=\ddot{\text{O}} \leftrightarrow \ddot{\text{O}}=\text{S}-\ddot{\text{O}}:$
 - e) $:\ddot{\text{O}}-\text{S}=\ddot{\text{O}} \leftrightarrow :\ddot{\text{O}}=\text{S}-\ddot{\text{O}}:$

4. How many unhybridized p-atomic orbitals are there on an sp hybridized carbon atom?
- a) 0
 - b) 1
 - c) 2
 - d) 3
 - e) 4
5. Which one of the following metals is the most reactive?
- a) Li
 - b) Na
 - c) K
 - d) Cs
 - e) Rb
6. Which one of the following statements about the chemical properties of the alkali metals (Group IA) is correct?
- a) lowest ionization energy in a period
 - b) highest electron affinity in a period
 - c) nonmetallic character
 - d) tendency to form negative ions
 - e) smallest atomic radius in a period
7. Which of the following has the largest radius?
- a) O^{2-}
 - b) F^-
 - c) Ne
 - d) Na^+
 - e) Mg^{2+}
8. The ability of an atom in a molecule to attract electron density to itself is termed
- a) paramagnetism
 - b) diamagnetism
 - c) electronegativity
 - d) electron affinity
 - e) ionization potential
9. Which element below has the lowest electronegativity?
- a) Be
 - b) F
 - c) Si
 - d) Cl
 - e) Mg
10. The following molecule has _____ σ and _____ π bonds, respectively.



- a) 4 and 2
- b) 2 and 4
- c) 2 and 2
- d) 2 and 6
- e) 6 and 2

11. Which carbon to nitrogen bond is the longest?

- a) C—N
- b) C=N
- c) C≡N
- d) All carbon to nitrogen bonds are equal in length.

12. Which of the following Lewis structures best represents the bonding in POCl based on minimizing the formal charges of the atoms?

- a) $\ddot{\text{O}}=\text{P}=\ddot{\text{Cl}}:$
- b) $:\ddot{\text{O}}-\ddot{\text{P}}-\ddot{\text{Cl}}:$
- c) $\ddot{\text{O}}=\text{P}=\ddot{\text{Cl}}$
- d) $:\ddot{\text{O}}-\ddot{\text{P}}-\ddot{\text{Cl}}:$
- e) $\ddot{\text{O}}-\ddot{\text{P}}-\ddot{\text{Cl}}:$

13. Which one of the following elements has the largest first ionization energy?

- a) Na
- b) Rb
- c) Al
- d) Te
- e) Cl

14. How many equivalent resonance forms can be drawn for NO_2^- ?

- a) 1
- b) 2
- c) 3
- d) 4
- e) There are no resonance structures for this ion.

15. What is the oxidation number of S in S_2O_4 ?

- a) -2
- b) +2
- c) +3
- d) -4
- e) +4

16. The hybridization of iodine in IF_5 is

- a) sp^2
- b) sp
- c) sp^3
- d) sp^3d
- e) sp^3d^2

17. The bond angle in the BF_2^- ion is closest to

- a) 90°
- b) 100°
- c) 120°
- d) 180°
- e) 135°

18. Which one of the following molecules has an overall dipole moment?

- a) CO_2
- b) XeF_4
- c) BF_3
- d) SO_2
- e) CCl_4

19. The hybridization of C in $H-C\equiv N$: is

- a) sp
- b) sp^3d^2
- c) sp^3d^2
- d) sp^2
- e) sp^3

20. The sp^3d^2 hybrid orbital set contains how many orbitals?

- a) 2
- b) 3
- c) 4
- d) 5
- e) 6

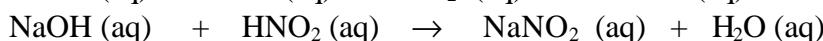
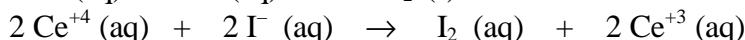
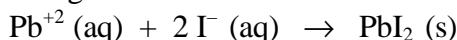
21. A triple bond consists of

- a) three sigma bonds

- b) one sigma and two pi bonds
c) three pi bonds
d) two sigma and one pi bond
e) none of the above
22. The molecular geometry for the chlorate ion (ClO_3^-) is best described as
a) tetrahedral
b) "T" shaped
c) trigonal pyramidal
d) trigonal planar
e) octahedral
23. How many lone (nonbonding) pairs of electrons are on the central atom of SF_4 ?
a) 0
 b) 1
c) 2
d) 3
e) 4
24. What is the ideal bond angle for the C-O-C bond in the molecule shown below?
- a) 180°
 b) 120°
c) 109°
d) 90°
e) 135°
25. Which one of the following ions has the electron configuration $[\text{Ar}]3d^4$?
a) Mn^{2+}
 b) Cr^{2+}
c) V^{3+}
d) Fe^{3+}
e) Co^{3+}
26. What is the geometry of PF_4^+ ?
 a) Tetrahedral
b) "T" shaped
c) See saw
d) Square planar
e) Octahedral
27. The species below which does not obey the octet rule is
a) NF_3

- b) IF_3
- c) PF_3
- d) SbF_3
- e) AsF_3

1. The following reactions:



are examples of

- a) precipitation, redox, and acid-base reactions, respectively.
 - b) unbalanced reactions.
 - c) precipitation, acid-base, and redox reactions, respectively.
 - d) redox, acid-base, and precipitation reactions, respectively.
 - e) acid-base reactions.
2. If you were to make an aqueous solution of silver nitrate, $\text{AgNO}_3(\text{aq})$, and take a pure copper penny and place it in the solution, the following would happen:
- a) No reaction at all since silver is more active than copper.
 - b) The copper on the surface of the penny would oxidize and a coating of silver would form.
 - c) All solids would dissolve.
 - d) Silver would be oxidized and copper would be reduced.
 - e) A coating of silver would form on the totally unreacted penny.
3. What is the concentration of the solution prepared by diluting 0.200 L of a 2.00 M solution to a final volume of 0.800 L?
- a) 8.00 M
 - b) 0.200 M
 - c) 0.500 M
 - d) 0.400 M
 - e) 0.800 M
4. What is the correct formula for potassium sulfite?
- a) KSO_4
 - b) K_2SO_3
 - c) K_2SO_4
 - d) K_2SO_5
 - e) P_2SO_4
5. The proper name for N_2O_5 is
- a) nitrogen pentoxide
 - b) pentaoxygen dinitride
 - c) dinitrogen tetroxide
 - d) dinitrogen pentoxide
 - e) nitrous oxide

6. HNO_3 is a _____, $\text{Cu}(\text{OH})_2$ is a _____, and NaNO_3 is a _____.

The blanks in the sentence above should be filled in with which of the respective classifications?

- a) strong acid, strong base, weak base
- b) weak base, weak acid, salt
- c) salt, base, salt
- d) weak acid, strong base, salt
- e) strong acid, weak base, salt

7. The balanced molecular equation for complete neutralization of H_2SO_4 by KOH in aqueous solution is

- a) $\text{H}_2\text{SO}_4 \text{ (aq)} + 2 \text{ KOH} \text{ (aq)} \rightarrow 2 \text{ H}_2\text{O} \text{ (l)} + \text{K}_2\text{SO}_4 \text{ (s)}$
- b) $\text{H}^+ \text{ (aq)} + \text{KOH} \text{ (aq)} \rightarrow \text{H}_2\text{O} \text{ (l)} + \text{K}^+ \text{ (aq)}$
- c) $\text{H}_2\text{SO}_4 \text{ (aq)} + 2 \text{ OH}^- \text{ (aq)} \rightarrow 2 \text{ H}_2\text{O} \text{ (l)} + \text{SO}_4^{2-} \text{ (aq)}$
- d) $\text{H}^+ \text{ (aq)} + \text{OH}^- \text{ (aq)} \rightarrow 2 \text{ H}_2\text{O} \text{ (l)}$
- e) $\text{H}_2\text{SO}_4 \text{ (aq)} + 2 \text{ KOH} \text{ (aq)} \rightarrow 2 \text{ H}_2\text{O} \text{ (l)} + \text{K}_2\text{SO}_4 \text{ (aq)}$

8. Which of the following are oxidation-reduction reactions?

- I. $\text{PCl}_3 \text{ (l)} + \text{Cl}_2 \text{ (g)} \rightarrow \text{PCl}_5 \text{ (l)}$
- II. $\text{Cu} \text{ (s)} + 2 \text{ AgNO}_3 \text{ (aq)} \rightarrow \text{Cu}(\text{NO}_3)_2 \text{ (aq)} + 2 \text{ Ag} \text{ (s)}$
- III. $\text{H}_2\text{CO}_3 \text{ (aq)} + 2 \text{ LiOH} \text{ (aq)} \rightarrow \text{Li}_2\text{CO}_3 \text{ (aq)} + 2 \text{ H}_2\text{O} \text{ (l)}$
- IV. $\text{FeCl}_2 \text{ (aq)} + 2 \text{ NaOH} \text{ (aq)} \rightarrow \text{Fe}(\text{OH})_2 \text{ (s)} + 2 \text{ NaCl} \text{ (aq)}$

- a) I and II
- b) IV
- c) III
- d) I, II, and III
- e) I, II, III, and IV

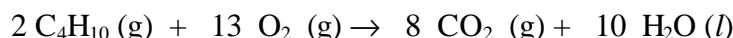
9. What is the proper name for $\text{Fe}(\text{NO}_3)_3$?

- a) iron (II) nitrate
- b) iron (III) nitrate
- c) iron (II) nitrite
- d) iron (III) nitrite
- e) ferrous nitrate

10. A much sought-after high explosive has the following composition: C, 20.7%; N, 24.1 %; O, 55.2%. What is its empirical formula?

- a) CNO_2
- b) CNO_3
- c) $\text{C}_4\text{N}_2\text{O}_4$
- d) C_2NO_2
- e) $\text{C}_2\text{N}_2\text{O}_6$

11. In the combustion of butane (C_4H_{10}), the amount of carbon dioxide produced by burning 5.80 g of C_4H_{10} is:



- a) 88.0 g

- b) 17.6 g
- c) 8.80 g
- d) 64.8 g
- e) 4.40 g

12. The correct name for HNO_2 is

- a) hydronitric acid.
- b) nitrous acid.
- c) hyponitric acid.
- d) pernitrous acid.
- e) nitric acid.

13. Solubility rules predict that a precipitate will form when mixing 0.1 M aqueous solutions of

- a) NiBr_2 and AgNO_3
- b) NaI and KBr
- c) K_2SO_4 and CrCl_3
- d) KOH and $\text{Ba}(\text{NO}_3)_2$
- e) Li_2CO_3 and CsI

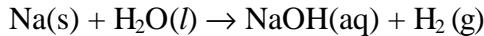
14. Calculate the number of moles in 38.4 g of $\text{C}_4\text{H}_6\text{O}_4$.

- a) 3.08 mol
- b) 4.53×10^3 mol
- c) 0.325 mol
- d) 38.4 mol
- e) 2.31×10^{25} mol

15. Fulvene has the molecular formula C_6H_6 . What is the weight percent of carbon in fulvene?

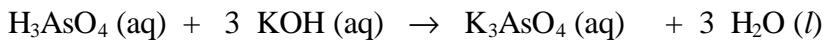
- a) 50.0 %
- b) 7.71 %
- c) 12.0 %
- d) 92.3 %
- d) 6.00 %

16. What is the coefficient of H_2 when the following equation is correctly balanced?



- a) 1
- b) 2
- c) 3
- d) 4
- e) 5

17. If 35.21 mL of 0.1894 M KOH is required to neutralize 25.00 mL of an aqueous solution of arsenic acid (H_3AsO_4), what is the concentration of the arsenic acid solution?



- a) 0.2668 M
- b) 0.8003 M
- c) 0.08892 M
- d) 0.1345 M
- e) 0.1778 M

18. Which ion(s) is/are spectator ions in the formation of a precipitate of $BaSO_4$ via combining aqueous solutions of BaI_2 and K_2SO_4 ?

- a) Ba^{2+} only
- b) K^+ only
- c) SO_4^{2-} and I^-
- d) K^+ and I^-
- e) Ba^{2+} and SO_4^{2-}

19. Calculate the number of oxygen atoms in 2.00 moles of Mn_2O_7 .

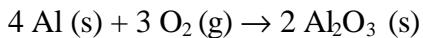
- a) 0.009 atoms
- b) 8.43×10^{24} atoms
- c) 1.20×10^{24} atoms
- d) 444.0 atoms
- e) 14.0×10^{24} atoms

20. How many moles of H_2CO_3 are required to produce 11.0 g of CO_2 according to the equation:



- a) 0.50 mol
- b) 1.00 mol
- c) 11.00 mol
- d) 0.25 mol
- e) 2.00 mol

21. Calculate the number of grams of Al_2O_3 that could be produced if 2.5 g of aluminum and 2.5 g of oxygen were allowed to react according to the following balanced equation.



- a) 4.7 g
- b) 7.4 g
- c) 9.4 g
- d) 5.3 g
- e) 10.0 g

22. What are the products produced when $Mg(OH)_2$ reacts with H_3PO_4 ?

- a) $Mg_3(PO_4)_2$ and $H_3(OH)_2$
- b) No reaction occurs
- c) $(OH)_3PO_4$ and HMg
- d) $Mg_3(PO_4)_2$ and H_2O



23. For a substance to be considered a strong electrolyte, it must

- a) be an ionic compound.
- b) dissociate virtually completely into ions in solution.
- c) be highly soluble in water.
- d) contain both metal and nonmetal atoms.
- e) be a covalent compound.

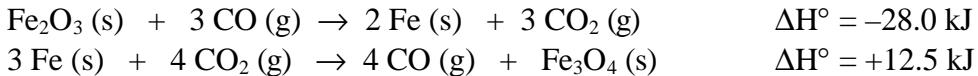
24. Which one of the following samples contains the largest number of atoms?

- a) 2.5 mol CH_4
- b) 10.0 mol He
- c) 7.0 mol Cl_2
- d) 4.0 mol SO_2
- e) 1.8 mol S_8

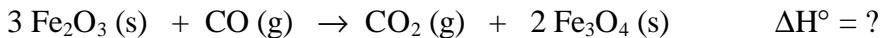
25. How many moles of Br^- are present in 0.500 L of 0.300 M NaBr ?

- a) 0.150 mol
- b) 0.167 mol
- c) 0.450 mol
- d) 0.0500 mol
- e) 0.500 mol

1. Given the following thermochemical equations:

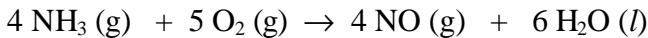


Calculate the value of ΔH° for the following reaction:



- a) -28.0 kJ
- b) +40.5 kJ
- c) -15.5 kJ
- d) -59.0 kJ
- e) -109 kJ

2. Calculate the value of $\Delta H^\circ_{\text{rxn}}$ (in kJ) for the following reaction:



Given the following ΔH_f° values: $\text{H}_2\text{O}(\text{l}) = -286 \text{ kJ/mol}$, $\text{NO}(\text{g}) = +90 \text{ kJ/mol}$, $\text{NH}_3(\text{g}) = -46 \text{ kJ/mol}$.

- a) -242 kJ
- b) -150 kJ
- c) -1540 kJ
- d) -1172 kJ
- e) -1892 kJ

3. A sample of nitrogen gas has a volume of 32.4 L at 20 °C. The gas is heated to 220 °C at constant pressure. What is the final volume of nitrogen?

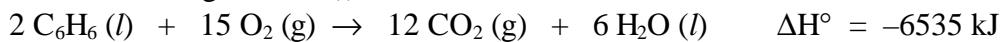
- a) 356 L
b) 19.3 L
c) 31.4 L

(d) 54.5 L
e) 2.94 L

4. Which one of the following statements is incorrect for an ideal gas, according to the Kinetic Molecular Theory?

- a) Molecules of a gas are widely separated from one another.
b) Molecules of a gas occupy negligible volume.
c) Molecules of a gas move with an average speed determined by the temperature.
d) Molecules of a gas move in straight paths until collisions occur with other molecules or the walls of the container.
e) Molecules of a gas exert attractive and repulsive forces on each other.

5. The value of ΔH° for the following reaction is -6535 kJ. How many kJ of heat will be evolved during the combustion of 16.0 g of $C_6H_6(l)$?



- a) 2.68×10^3
b) 5.23×10^4
c) 670
d) 1.34×10^3
e) 6535

6. Determine the molar mass of Freon-11 gas if a sample weighing 0.597 g occupies 100 mL at 95 °C and 1000 mmHg.

- a) 137 g/mol
b) 35.3 g/mol
c) 70.9 g/mol
d) 0.19 g/mol
e) 384 g/mol

7. A mixture of three gases has a total pressure at 298 K of 1380 mmHg. The mixture is analyzed and is found to contain 1.27 mol CO_2 , 3.04 mol CO, and 1.50 mol Ar. What is the partial pressure of Ar?

- a) 5345 mmHg (7.03 atm)
b) 301 mmHg (0.396 atm)
c) 356 mmHg (0.468 atm)
d) 196 mmHg (0.258 atm)
e) 8020 mmHg (10.6 atm)

8. Deviations from the Ideal Gas Equation are greater at:

- a) high temperatures and low pressures
b) low temperatures and high pressures
c) high temperatures and high pressures
d) low temperatures and low pressures

- e) Gases do not deviate from the Ideal Gas Equation.
9. Which one of the following gases will diffuse the fastest at a given temperature?
- a) SF₆
 b) CH₄
 c) Ar
 d) NH₃
 e) HBr
10. Which one of the following ionic compounds would have the highest lattice energy?
- a) MgO
 b) MgCl₂
 c) RbF
 d) LiF
 e) SrO
11. The symbol ΔH_f° [HNO₃ (l)] refers to which one of the following reactions occurring at 25 °C?
- a) HNO₃ (l) \rightarrow H(g) + N₂ (g) + O₃ (g)
 b) $\frac{1}{2}$ H₂ (g) + $\frac{1}{2}$ N₂ (g) + $\frac{3}{2}$ O₂ (g) \rightarrow HNO₃ (l)
 c) H(g) + N₂ (g) + O₃ (g) \rightarrow HNO₃ (l)
 d) HNO₃ (l) \rightarrow $\frac{1}{2}$ H₂ (g) + $\frac{1}{2}$ N₂ (g) + $\frac{3}{2}$ O₂ (g)
 e) H₂ (g) + N₂ (g) + O₃ (g) \rightarrow HNO₃ (l)
12. Given: $2 \text{Al (s)} + \frac{3}{2} \text{O}_2 \text{ (g)} \rightarrow \text{Al}_2\text{O}_3 \text{ (s)}$ $\Delta H^\circ = -1670 \text{ kJ}$
 What is ΔH° for the reaction:
 $2 \text{Al}_2\text{O}_3 \text{ (s)} \rightarrow 4 \text{Al (s)} + 3 \text{O}_2 \text{ (g)}$ $\Delta H^\circ = ?$
- a) -3340 kJ
 b) +1670 kJ
 c) +3340 kJ
 d) -1670 kJ
 e) -835 kJ
13. When calculating $\Delta H_{\text{rxn}}^\circ$ for the following reaction using heats of formation, which species will have a $\Delta H_f^\circ = 0 \text{ kJ}$?
- $$\text{Ni (s)} + 2 \text{CO (g)} + 2 \text{PF}_3 \text{ (g)} \rightarrow \text{Ni(CO)}_2(\text{PF}_3)_2 \text{ (l)}$$
- a) both CO (g) and PF₃ (g)
 b) CO (g)
 c) PF₃ (g)
 d) Ni (s)
 e) Ni(CO)₂(PF₃)₂ (l)
14. Calculate the value of ΔE for a system that loses 50 J of heat and has 150 J of work performed on it by the surroundings.

- a) -100 J
- b) 100 J
- c) 50 J
- d) -200 J
- e) 200 J

15. A small bubble rises from the bottom of a lake, where the temperature and pressure are $4\text{ }^{\circ}\text{C}$ and 3.0 atm, to the water's surface, where the temperature is $25\text{ }^{\circ}\text{C}$ and pressure is 0.95 atm. Calculate the final volume of the bubble if its initial volume was 2.1 mL.

- a) 41.4 mL
- b) 6.2 mL
- c) 0.72 mL
- d) 22.4 mL
- e) 7.1 mL

16. A sample of aluminum absorbed 9.86 J of heat and its temperature increased from $23.2\text{ }^{\circ}\text{C}$ to $30.5\text{ }^{\circ}\text{C}$. What was the mass of the aluminum sample? The specific heat of aluminum is $0.90\text{ J/g }^{\circ}\text{C}$.

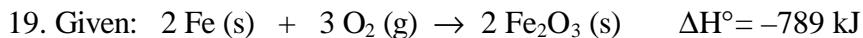
- a) 6.7 g
- b) 72 g
- c) 65 g
- d) 8.1 g
- e) 1.5 g

17. A sample of hydrogen gas, H_2 , was collected over water at $21\text{ }^{\circ}\text{C}$ and 685 mmHg. The volume of the container was 7.80 L. Calculate the mass of H_2 collected. (Vapor pressure of water at $21\text{ }^{\circ}\text{C}$ = 18.6 mmHg.)

- a) 435 g
- b) 0.283 g
- c) 0.589 g
- d) 7.14 g
- e) 0.572 g

18. A gas evolved during the fermentation of sugar was collected at $22.5\text{ }^{\circ}\text{C}$ and 702 mmHg. After purification, its volume was found to be 25.0 L. How many moles of gas were collected?

- a) 1.05 mol
- b) 0.95 mol
- c) 12.5 mol
- d) 22.4 mol
- e) 724 mol



The reaction shown above is _____ and therefore heat is _____ by the reaction.

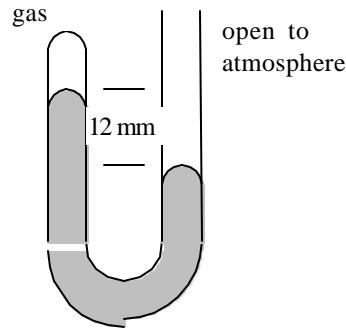
- a) exothermic, released
- b) endothermic, absorbed
- c) endothermic, released
- d) exothermic, absorbed
- e) none of the above

20. A 1.96 g sample of titanium was burned in a bomb calorimeter. The bomb calorimeter has a heat capacity of 9.84 kJ/ $^\circ\text{C}$. The temperature of the calorimeter increased from $36.84 \text{ }^\circ\text{C}$ to $98.82 \text{ }^\circ\text{C}$. How much heat would be released from the combustion of one mole of titanium?

- a) 610 kJ
- b) 62.0 kJ
- c) 1200 kJ
- d) 311 kJ
- e) $1.49 \times 10^4 \text{ kJ}$

21. What is the pressure of the gas trapped in the closed end of the apparatus shown when the atmospheric pressure is 720 mmHg? The Hg level in the closed end is 12 mm higher than than in the open end .

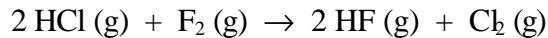
- a) 708 mmHg
- b) 12 mmHg
- c) 720 mmHg
- d) 732 mmHg
- e) 760 mmHg



22. What is the molar mass of a gas that effuses through a small hole at twice the rate as oxygen gas, O_2 , at the same temperature?

- a) 8.0 g/mol
- b) 64 g/mol
- c) 23 g/mol
- d) 16 g/mol
- e) 128 g/mol

23. Use the bond dissociation energies given below to determine the value of ΔH (in kJ) for the following reaction:

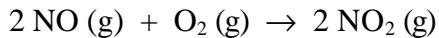


$$D(\text{H-Cl}) = 432 \text{ kJ/mol} \quad D(\text{F-F}) = 155 \text{ kJ/mol}$$

$$D(\text{H-F}) = 567 \text{ kJ/mol} \quad D(\text{Cl-Cl}) = 242 \text{ kJ/mol}$$

- a) +579 kJ
- b) -222 kJ
- c) +357 kJ
- d) +222 kJ
- e) -357 kJ

24. Using the following equation, determine the volume of oxygen gas at 320 K and 680 torr which will react with 2.50 L of NO gas at the same temperature and pressure.



- a) 5.00 L
- b) 2.50 L
- c) 3.00 L
- d) 1.25 L
- e) 1.00 L

25. A 24.2 g sample of oxygen gas, O₂, initially at 4.00 atm is compressed from 8.00 L to 2.00 L at constant temperature. What is the resulting pressure in atm of the gas?

- a) 8.00 atm
- b) 2.00 atm
- c) 1.00 atm
- d) 4.00 atm
- e) 16.0 atm

26. Which of the following statements concerning Kinetic Molecular Theory is correct?

- a) At a given temperature molecules with a greater molar mass will have a higher average kinetic energy.
- b) Molecules with a greater molar mass will have a higher velocity.
- c) The average kinetic energy of a gas is dependent on temperature and independent of molar mass and velocity.
- d) As the temperature of a gas increases, the average kinetic energy decreases.
- e) The average kinetic energy of a gas is dependent on temperature, molar mass, and velocity.

27. Calculate the density in g/L of CO₂ gas at 27 °C and 0.50 atm pressure.

- a) 9.93 g/L
- b) 1.12 g/L
- c) 46.0 g/L
- d) 0.89 g/L
- e) 0.101 g/L

28. The average fuel value of sugar is 17 kJ/g. A 2.0 L pitcher of sweetened Kool-Aid contains 400 g of sugar. What is the fuel value (in kJ) of a 500 mL serving of Kool-Aid? (Assume the sugar is the only fuel source.)

- a) 1.7×10^2
- b) 1.7×10^3
- c) 1.7×10^6
- d) 4.2×10^4
- e) 6.8×10^3

1. Which of the following is most volatile?

- A) CBr₃H
- B) CCl₄
- C) CCl₃H
- D) CBr₄
- E) CBr₂H₂

2. The boiling point of O₂ is higher than N₂ due to

- A) hydrogen bonding. D) London forces.
B) ion-ion forces. E) dipole-dipole forces.
C) ion-dipole forces.

4. Aluminum has a face-centered cubic unit cell. If the atomic radius of aluminum is 125 pm, what is the edge length of the unit cell?

- A) 177 pm B) 354 pm C) 217 pm D) 500 pm E) 250 pm

3. The meniscus of mercury curves downward in a glass tube forming a "⌞" shape. This means

- A) mercury tends to cover the greatest possible area of the glass.
B) the cohesive forces between mercury atoms are not as strong as the adhesive forces between mercury and glass.
C) mercury has a low surface tension.
D) the cohesive forces between mercury atoms are stronger than the adhesive forces between mercury and glass.
E) mercury has a large capillary action.

5. Which of the following has the highest vapor pressure at room temperature?

- A) acetic acid, CH_3COOH D) ethanol, $\text{CH}_3\text{CH}_2\text{OH}$
B) dimethylether, CH_3OCH_3 E) water, H_2O

1. Which of the following has the highest boiling point?

- A) I_2 B) Br_2 C) F_2 D) Cl_2 E) Ar

2. The boiling point of HF is higher than HCl due to

- A) ion-dipole forces. D) dipole-dipole forces.
B) hydrogen bonding. E) ion-ion forces.
C) London forces.

4. If gold has a face-centered cubic unit cell, how many atoms of gold does the unit cell contain?

- A) 4 B) 7 C) 2 D) 5 E) 14

5. The vapor pressure of water above 50 mL of water in a 60-mL closed container is 23.8 Torr at 25°C. What is the vapor pressure of water if the volume of the container is changed to 100 mL?

- A) 11.9 Torr B) about 26 Torr C) 23.8 Torr D) 39.7 Torr E) 15.9 Torr

1. Which of the following has the highest boiling point?

- A) *n*-butane, $\text{CH}_3(\text{CH}_2)_2\text{CH}_3$ D) *n*-propane, $\text{CH}_3\text{CH}_2\text{CH}_3$
B) *n*-hexane, $\text{CH}_3(\text{CH}_2)_4\text{CH}_3$ E) *n*-pentane, $\text{CH}_3(\text{CH}_2)_3\text{CH}_3$
C) *n*-heptane, $\text{CH}_3(\text{CH}_2)_5\text{CH}_3$

2. For which of the following substances would hydrogen bonding be most important?

- A) NH_3 B) HI C) CH_4 D) H_2 E) GeH_4

3. Silver has a face-centered cubic unit cell. If the atomic radius of silver is 145 pm, what is the edge length of the unit cell?

- A) 251 pm B) 410 pm C) 290 pm D) 580 pm E) 205 pm

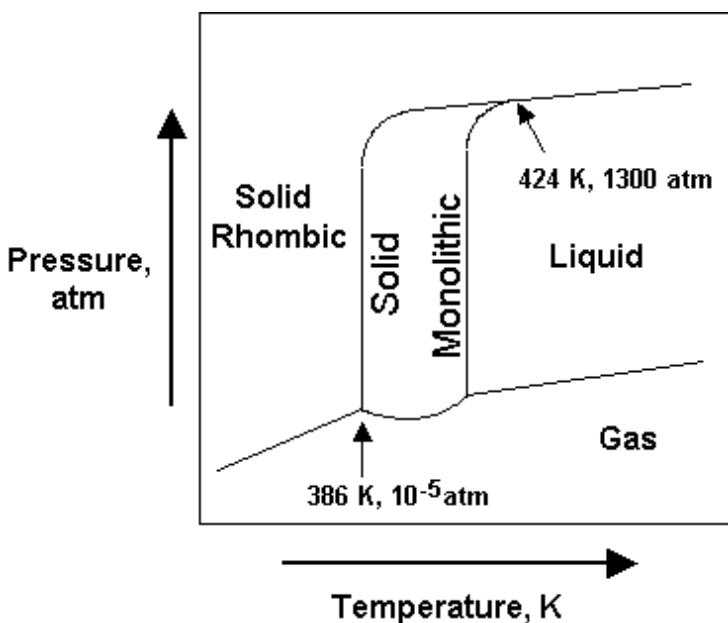
4. In which of the following would the boiling point of water be highest?

- A) at the peak of Mt. Everest
B) in a pressure cooker where the pressure is 1400 Torr
C) in the "mile high" city of Denver
D) in New York city where the pressure is about 760 Torr
E) in New Mexico where the pressure is about 710 Torr

1. The molality of a solution is defined as

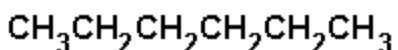
- A) moles of solute per liter of solution.
B) grams of solute per liter of solution.
C) moles of solute per kilogram of solution.
D) moles of solute per kilogram of solvent.
E) the gram molecular weight of solute per kilogram of solvent.

5. The phase diagram for sulfur is given below. At 430 K, what pressure should be applied to completely melt rhombic sulfur?

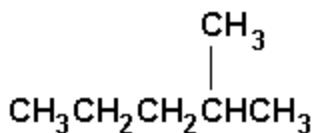


- A) 1000 atm
B) rhombic sulfur sublimes instead of melting
C) 1400 atm
D) 1300 atm
E) 10^{-5} atm

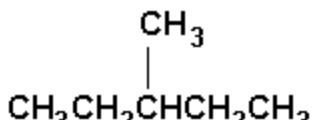
1. Consider the following molecules, all with molecular formula C_6H_{14} :



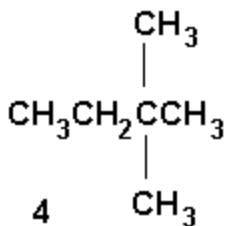
1



2



3



4

Which has the highest boiling point?

- A) 1
- B) 2
- C) 3
- D) 4

- E) All have the same boiling point because they have the same molecular formula.

2. Which of the following concentrations can change with a change in temperature?

- 1. molality
- 2. molarity
- 3. mole percentage

- A) 1 only
- B) 2 only
- C) 3 only
- D) 1 and 2 only
- E) 2 and 3 only

3. What mass of 40.0% glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, solution contains 75.0 g of water?

- A) 40.0 g
- B) 50.0 g
- C) 125 g
- D) 150. g
- E) 175 g

4. What is the molarity of an NaI solution that contains 3.00 g of NaI in 40.0 mL of solution?

- A) 0.100 M
- B) 0.500 M
- C) 1.00 M
- D) 2.00 M
- E) 5.00 M

5. What is the percent Na_2SO_4 by mass in a 1.00 molal aqueous solution?

- A) 12.4
- B) 13.6
- C) 14.2
- D) 15.8
- E) 16.2

6. To obtain 12 g of sucrose ($\text{MM} = 342$) from a solution labeled 8.0% $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ by mass, we would need to weigh out _____ of solution.

- A) 25 g
- B) 50 g
- C) 100 g
- D) 150 g
- E) 200 g

7. A 12.0% sucrose solution has a density of 1.05 g/cm^3 . The number that gives the best value for mass of sugar in 55 mL of this solution is

- A) 6.6 g.
- B) 6.60 g.
- C) 6.9 g.
- D) 6.93 g.
- E) 58 g.

8. Which of the following affect the solubility of gases in solvents?

1. the nature of the gas
 2. the density of the solvent
 3. the temperature of the solvent
- A) 1 only
 - B) 2 only
 - C) 3 only
 - D) 1 and 3 only
 - E) 1, 2, and 3

9. Sparkling wine is bottled under a CO_2 pressure of 4.0 atm. The solubility of CO_2 at 4.0 atm is $0.68 \text{ g}/100 \text{ g H}_2\text{O}$. What is its solubility after the bottle is opened if the partial pressure of CO_2 is $4.0 \times 10^{-4} \text{ atm}$?

- A) $1.35 \times 10^{-5} \text{ g}/100 \text{ g H}_2\text{O}$
- B) $6.8 \times 10^{-5} \text{ g}/100 \text{ g H}_2\text{O}$
- C) $5.1 \times 10^{-6} \text{ g}/100 \text{ g H}_2\text{O}$
- D) $2.72 \times 10^{-5} \text{ g}/100 \text{ g H}_2\text{O}$
- E) $5.8 \times 10^{-4} \text{ g}/100 \text{ g H}_2\text{O}$

10. Which compound below would be expected to be the least soluble in water?

- A) $\text{CH}_3\text{CH}_2\text{CH}_2\text{F}$
- B) $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$
- C) $\text{CH}_3\text{CH}_2\text{OHCH}_3$
- D) $\text{CH}_3\text{CH}_2\text{COOH}$
- E) $\text{CH}_3\text{CH}_2\text{NHCH}_3$

11. All the following compounds are correctly described except

- A) KOH , a very soluble base in water.
- B) HCl , a very soluble acid in water.
- C) CH_3OH , a very soluble base in water.
- D) N_2H_4 , a very soluble base in water.
- E) CCl_4 , a very soluble liquid in benzene.

12. Which of the following are colligative properties?

1. osmotic pressure
2. vapor pressure
3. density
4. freezing-point depression
5. boiling point

- A) 1 and 2 only
- B) 1 and 4 only
- C) 2 and 4 only
- D) 2, 3, and 5 only
- E) 1, 2, and 5 only

13. What is the mole fraction of ethanol, $\text{C}_2\text{H}_5\text{OH}$, in a methanol solution that is 40% methanol, CH_3OH , by mass?

- A) 0.40
- B) 0.46
- C) 0.51
- D) 0.54
- E) 0.60

14. When 0.100 mol of urea, a nonelectrolyte whose MW = 60.1 and whose density = 1.48 g/cm³, is dissolved in 100.0 g of water ($K_f = 1.86^\circ\text{C/molal}$), the molality of the solution is

- A) 1.86 m.
- B) 1.00 m.
- C) 0.500 m.
- D) 0.186 m.
- E) 0.100 m.

15. The vapor pressure of a solution containing a nonvolatile solute is directly proportional to the

- A) mole fraction of the solute.
- B) mole fraction of the solvent.
- C) molarity of the solvent.
- D) osmotic pressure of the solute.
- E) molality of the solvent.

16. Which of the following has the highest vapor pressure at room temperature?

- A) Ethylene glycol, b.p. = 198°C
- B) Ethanol, b.p. = 78°C
- C) Water, b.p. = 100°C
- D) Benzene, b.p. = 80°C
- E) Carbon disulfide, b.p. = 46°C

17. Determine the freezing point of a 0.25 m solution of glucose in water. (K_f for water is 1.86°C/m.)

- A) 0.93°C
- B) -0.93°C
- C) 0.46°C
- D) -0.46°C
- E) 0.23°C

19. Which of the following solutions has the lowest osmotic pressure?

- A) 0.15 M NaCl
- B) 0.10 M CaCl_2
- C) 0.15 M $\text{Ba}(\text{NO}_3)_2$
- D) 0.20 M NH_3
- E) 0.10 M $\text{Al}(\text{NO}_3)_3$