

Formulas and Constants

Thermochemistry

$$\Delta H^\circ_{\text{rxn}} = \sum n \Delta H^\circ(\text{products}) - \sum n \Delta H^\circ(\text{reactants})$$

$$\Delta H^\circ_{\text{rxn}} = \sum n \Delta H^\circ(\text{enthalpies of bonds broken}) - \sum n \Delta H^\circ(\text{enthalpies of bonds formed})$$

$$q = mC_s(T_F - T_I)$$

Properties of Electromagnetic Radiation

$$E = hc/\lambda = h\nu$$

$$\lambda\nu = c$$

DeBroglie Relationship

$$\lambda = h/(mv)$$

Potential Energy of Two Interacting Charges

$$E = k (Q_1Q_2)/d$$

Physical Constants

$$\text{Avogadro's Number} \rightarrow N = 6.022 \times 10^{23}$$

$$\text{Planck's Constant} \rightarrow h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$$

$$\text{Speed of Light} \rightarrow c = 3.00 \times 10^8 \text{ m/s}$$

$$\text{Rydberg's Constant} \rightarrow R_H = 1.10 \times 10^7 \text{ m}^{-1}$$

$$\text{Charge of an Electron} \rightarrow e = 1.602 \times 10^{-19} \text{ C}$$

$$\text{Temperature Conversions} \rightarrow \text{K} = 273 + ^\circ\text{C}$$

$$\text{STP} \rightarrow 273 \text{ K and } 1 \text{ atm}$$

$$1 \text{ mL} = 1 \text{ cm}^3$$

1. [7.5 points] How many electrons, protons and neutrons does $^{43}\text{Ca}^{2+}$ have?

- (a) 20 protons, 23 neutrons and 18 electrons
- (b) 23 protons, 20 neutrons and 21 electrons
- (c) 20 protons, 23 neutrons and 20 electrons
- (d) 20 protons, 18 neutrons and 23 electrons
- (e) none of the above are correct

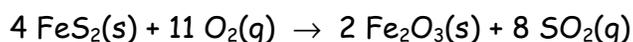
2. [7.5 points] What is the formula of chromium (III) oxide?

- (a) Cr_3O (b) CrO_3 (c) CrO (d) Cr_2O_3 (e) CrO_2

3. [7.5 Points] What is the empirical formula of the ionic compound that forms between calcium and sulfur?

- (a) CaS (b) Ca_2S (c) Ca_2S_3 (d) CaSO_4 (e) $\text{Ca}_3(\text{SO}_4)_2$

4. [7.5 points] What is the quantity of Fe_2O_3 that will be produced if 5.00 g of FeS_2 is reacted with 11.0 g of oxygen according to the following reaction:



- (a) 3.33 g
- (b) 9.98 g
- (c) 6.65 g
- (d) 1.55 g
- (e) 20.96 g

5. [7.5 Points] When 27.3 g of Fe powder is completely burned in air, an iron oxide is produced. The mass of the iron oxide should be:

- (a) less than 27.3 g because mass is lost on burning
- (b) equal to 27.3 g because matter is conserved in a chemical reaction
- (c) greater than 27.3 g because oxygen has been added to the iron
- (d) equal to 43.3 g which is equal to the initial mass of Fe plus the atomic mass of oxygen

6. [7.5 points] When a sample of ammonium nitrate dissolves in 100 g of water, the temperature changes from 25°C to 15°C. For this process:

- (a) ΔH is positive and the process is endothermic
- (b) ΔH is positive and the process is exothermic
- (c) ΔH is negative and the process is exothermic
- (d) ΔH is negative and the process is endothermic

7. [7.5 points] Strontium has three isotopes with mass numbers 86, 87 and 88. Their relative abundances are 9.9%, 7.0% and 82.6% respectively. How do the number of electrons and the electron configurations compare for atoms of the three isotopes?

- (a) Each has the same number of electrons and the same electron configuration
- (b) Each has different numbers of electrons and the same electron configuration
- (c) Each has different numbers of electrons and different electron configuration
- (d) It is impossible to decide because electron configurations do not apply to isotopes

8. [7.5 Points] If 258 mL of a 0.500 M $\text{Pb}(\text{NO}_3)_2$ solution is mixed with 500 mL of a 0.312 M NaI solution, what is the identity and mass of the precipitate that is formed?

- (a) Precipitate = PbI_2 , mass = 59.5 g
- (b) Precipitate = NaNO_3 , mass = 3.32 g
- (c) Precipitate = PbI_2 , mass = 36.0 g
- (d) Precipitate = PbI_2 , mass = 18.0 g
- (e) Precipitate = NaNO_3 , mass = 5.48 g

9. [7.5 Points] Which of the following metals will be oxidized to form cations if placed in a beaker of 1.0 M manganese (II) chloride solution?

- (a) Fe
- (b) Ag
- (c) Mg
- (d) Both (a) Fe and (b) Ag will be oxidized by a MnCl_2 solution
- (e) None of the above metals will be oxidized by a MnCl_2 solution

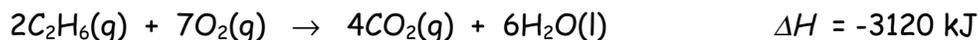
10. [7.5 Points] If 10.0 mL of 1.50 M NaOH solution is mixed with 25.0 mL of 0.750 M NaOH solution, what is the concentration of the resulting solution?

- (a) 1.12 M
- (b) 2.25 M
- (c) 0.0338 M
- (d) 1.25 M
- (e) 0.964 M

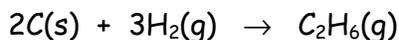
11. [7.5 points] Which of the following photons has the highest energy?

- (a) A photon with a wavelength of 2.50×10^{-6} m
- (b) A photon with a frequency of 6.00×10^{14} s⁻¹
- (c) A photon with a wavelength of 650 nm
- (d) A photon in the infrared region of the spectrum
- (e) A photon with energy of 9.94×10^{-19} J

12. [7.5 points] From the following enthalpies of reaction:

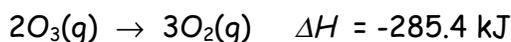


Calculate ΔH for the following reaction.



- (a) -86 kJ
- (b) -3206 kJ
- (c) -172 kJ
- (d) 1517 kJ
- (e) None of the above

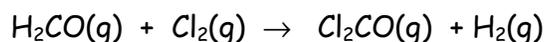
13. [7.5 points] Ozone (O_3) exothermically decomposes to give oxygen (O_2) according to the following reaction:



How much heat will be **released** by the decomposition of 15.0 g of ozone?

- (a) 44.6 kJ
(b) 89.2 kJ
(c) 285 kJ
(d) 66.9 kJ
(e) 155 kJ
14. [7.5 points] Which of the following photons has the highest energy?
- (a) A photon with a wavelength of $2.50 \times 10^{-6} \text{ m}$
(b) A photon with a frequency of $6.00 \times 10^{14} \text{ s}^{-1}$
(c) A photon with a wavelength of 650 nm
(d) A photon in the infrared region of the spectrum
(e) A photon with energy of $9.94 \times 10^{-19} \text{ J}$
15. [7.5 points] Which of the following ions has the greatest number of unpaired electrons?
- (a) Cr^{3+} (b) Co^{2+} (c) Zn^{2+} (d) Fe^{3+} (e) Ca^{2+}
16. [7.5 Points] What is the wavelength of a photon with energy of $8.66 \times 10^{-19} \text{ J}$?
- (a) 230 nm
(b) $1.31 \times 10^{15} \text{ m}$
(c) 315 nm
(d) 866 nm
(e) None of the above
17. [7.5 points] Arrange the following atoms in order of increasing electronegativity, F, Cl, S, P, As, Ca.
- | | | |
|---------------------------|--------------------------|----------------------|
| (a) Least Electronegative | F < Ca < As < P < S < Cl | Most Electronegative |
| (b) Least Electronegative | F < Cl < Ca < As < P < S | Most Electronegative |
| (c) Least Electronegative | Ca < As < P < S < F < Cl | Most Electronegative |
| (d) Least Electronegative | Ca < As < P < S < Cl < F | Most Electronegative |
| (e) Least Electronegative | F < Cl < S < P < As < Ca | Most Electronegative |

23. [7.5 points] Estimate ΔH for the reaction between formaldehyde and chlorine to form phosgene and hydrogen :



Using the following bond enthalpies as necessary:

C-O	358 kJ/mol	H-H	436 kJ/mol
C=O	799 kJ/mol	C-H	413 kJ/mol
C-Cl	328 kJ/mol	Cl-Cl	242 kJ/mol

- (a) -2160 kJ
(b) -109 kJ
(c) +109 kJ
(d) **-24 kJ**
(e) none of the above
24. [7.5 Points] Which of the following molecules does not violate the octet rule?
- (a) NO_2 (b) **GeF_4** (c) TeF_4 (d) BCl_3 (e) XeF_4
25. [7.5 points] Based on the Lewis dot structures, predict the ordering of N-O bond lengths in the following molecules: NO^+ , NO_2^- and NO_3^- .
- | | | |
|-------------------------------|---|--------------------------|
| (a) Shortest N-O bonds | $\text{NO}_3^- < \text{NO}_2^- < \text{NO}^+$ | Longest N-O bonds |
| (b) Shortest N-O bonds | $\text{NO}_2^- < \text{NO}_3^- < \text{NO}^+$ | Longest N-O bonds |
| (c) Shortest N-O bonds | $\text{NO}^+ < \text{NO}_2^- < \text{NO}_3^-$ | Longest N-O bonds |
| (d) Shortest N-O bonds | $\text{NO}^+ < \text{NO}_3^- < \text{NO}_2^-$ | Longest N-O bonds |
| (e) Shortest N-O bonds | $\text{NO}^+ < \text{NO}_3^- = \text{NO}_2^-$ | Longest N-O bonds |
26. [7.5 points] Using VSEPR theory, predict the molecular geometry of SF_4 .
- (a) tetrahedral (b) **see-saw** (c) T-shaped
(d) trigonal bipyramidal (e) square planar
27. [7.5 points] Using VSEPR theory, predict the molecular geometry of NF_3 .
- (a) tetrahedral (b) trigonal planar (c) T-shaped
(d) see-saw (e) **trigonal pyramidal**

28. [7.5 points] What is the hybrid orbital set used by the carbon atom in the molecule H_2CO ?

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

29. [7.5 points] Which of the following molecules is **not** linear.

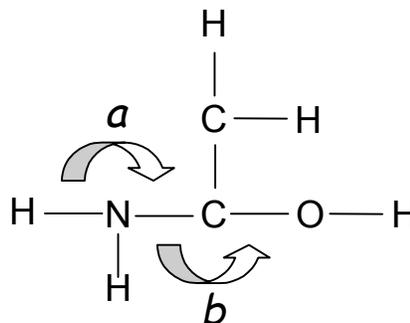
- (a) KrF_2
(b) HCN
(c) SO_2
(d) CO_2
(e) Both (a) KrF_2 and (c) SO_2 are non-linear

30. [7.5 points] Which of the following molecules are polar?

- (a) CH_4 (b) SF_6 (c) BF_3 (d) SO_2 (e) CO_2

31. [7.5 Points] What are the approximate bond angles, a and b , of the molecule given below?

- (a) $a \approx 109^\circ$ and $b \approx 109^\circ$
(b) $a \approx 109^\circ$ and $b \approx 120^\circ$
(c) $a \approx 120^\circ$ and $b \approx 109^\circ$
(d) $a \approx 90^\circ$ and $b \approx 180^\circ$



32. [7.5 points] How many σ and π bonds are there in C_2H_2 ?

- (a) 3 σ bonds and 1 π bond
(b) 2 σ bonds and 3 π bonds
(c) 3 σ bonds and 3 π bonds
(d) 5 σ bonds and 0 π bonds
(e) 3 σ bonds and 2 π bonds

33. [7.5 Points] Use molecular orbital theory to predict which molecule would have the shortest oxygen-oxygen bond distance?

- (a) O_2^-
(b) O_2
(c) O_2^+
(d) O_2^{2-}