Formulas and Constants

Thermochemistry

$\Delta H°_{rxn} = \Sigma \, n \, \Delta H°(products) - \Sigma \, n \, \Delta H°(reactants)$

$\Delta H°_{rxn} = \Sigma \, n \, \Delta H°(enthalpies\ of\ bonds\ broken) - \Sigma \, n \, \Delta H°(enthalpies\ of\ bonds\ formed)$

$q = mC_s(T_F - T_I)$

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
Avogadro's Number $\rightarrow N = 6.022 \times 10^{23}$
Planck's Constant $\rightarrow h = 6.626 \times 10^{-34}$ J-s
Speed of Light $\rightarrow c = 3.00 \times 10^8$ m/s
Rydberg's Constant $\rightarrow R_H = 1.10 \times 10^7$ m^{-1}
Charge of an Electron $\rightarrow e = 1.602 \times 10^{-19}$ C
Temperature Conversions $\rightarrow K = 273 + °C$
STP $\rightarrow$ 273 K and 1 atm
1 mL = 1 cm^3

1. **[7.5 points]** How many electrons, protons and neutrons does $^{43}Ca^{2+}$ 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) $Ca_3(SO_4)_2$

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:

$$4\ FeS_2(s) + 11\ O_2(g) \rightarrow 2\ Fe_2O_3(s) + 8\ SO_2(g)$$

    (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 $Pb(NO_3)_2$ 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 <u>will be oxidized</u> 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
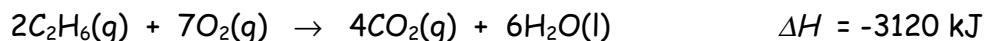   (e) None of the above metals will be oxidized by a $MnCl_2$ solution

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

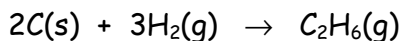11. **[7.5 points]** Which of the following photons has the highest energy?

(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:

$2C_2H_6(g)$ + $7O_2(g)$ → $4CO_2(g)$ + $6H_2O(l)$ ΔH = -3120 kJ
$C(s)$ + $O_2(g)$ → $CO_2(g)$ ΔH = -394 kJ
$2H_2(g)$ + $O_2(g)$ → $2H_2O(l)$ ΔH = -572 kJ

Calculate ΔH for the following reaction.

$$2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$$

(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:

$$2O_3(g) \rightarrow 3O_2(g) \quad \Delta H = -285.4 \text{ kJ}$$
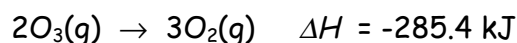
How much heat will be **released** by the decomposition of 15.0 g of ozone?

(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 2.50×10^{-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

15. **[7.5 points]** Which of the following ions has the greatest number of <u>unpaired electrons</u>?

(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 8.66×10^{-19}?

(a)   230 nm
(b) 1.31×10^{15} 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

18. **[7.5 points]** Arrange the following atoms in order of increasing electron affinity (EA): Br, As, Se, Kr.

(a) Least negative EA   Br < Se < As < Kr   Most negative EA
(b) Least negative EA   Kr < Br < Se < As   Most negative EA
(c) Least negative EA   As < Se < Br < Kr   Most negative EA
(d) Least negative EA   Kr < As < Se < Br   Most negative EA
(e) Least negative EA   Br < Kr < As < Se   Most negative EA

19. **[7.5 points]** Predict which molecule will have the **shortest** C-O bond?

(a) CO_3^{2-}
(b) CO_2
(c) H_2CO
(d) CO
(e) CH_3OH

20. **[7.5 points]** What is the **oxidation state** of sulfur in the sulfate ion, SO_4^{2-}?

(a) 0   (b) +2   (c) –2   (d) +8   (e) +6

21. **[7.5 points]** What is the **formal charge** on sulfur in the sulfate ion, SO_4^{2-}?

(a) 0   (b) +2   (c) –2   (d) +8   (e) +6

22. **[7.5 points]** Which of the following ionic compounds would you expect to have the largest lattice energy?

(a) KCl   (b) RbBr   (c) CsI   (d) SrSe   (e) CaO

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

$$H_2CO(g) + Cl_2(g) \rightarrow Cl_2CO(g) + H_2(g)$$
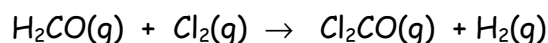
Using the following bond enthalpies as necessary:

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 <u>does not</u> 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　　$NO_3^- < NO_2^- < NO^+$　　Longest N-O bonds
(b) Shortest N-O bonds　　$NO_2^- < NO_3^- < NO^+$　　Longest N-O bonds
(c) Shortest N-O bonds　　$NO^+ < NO_2^- < NO_3^-$　　Longest N-O bonds
(d) Shortest N-O bonds　　$NO^+ < NO_3^- < NO_2^-$　　Longest N-O bonds
(e) Shortest N-O bonds　　$NO^+ < NO_3^- = NO_2^-$　　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**.
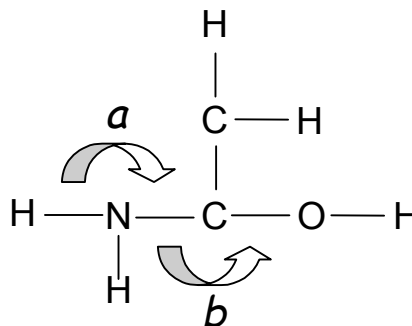
    (a) KrF_2
    (b) HCN
    (c) SO_2
    (d) CO_2
    (e) Both (a) KrF_2 and (c) SO_2 are non-linear

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) $a \approx 109°$ and $b \approx 109°$
    (b) $a \approx 109°$ and $b \approx 120°$
    (c) $a \approx 120°$ and $b \approx 109°$
    (d) $a \approx 90°$ and $b \approx 180°$

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-}