Version: A

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1. Energy is released when nitrogen gas combines with hydrogen gas to form ammonia according to the equation:

$$N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$$

Breaking Bonds requires energy.

Bond formation releases energy.

Which of the following is responsible for the release of energy?

A. Breaking nitrogen bonds
B. Breaking hydrogen bonds
C. Forming nitrogen-hydrogen bonds
D. Breaking both nitrogen and hydrogen bonds.
E. All of these release energy

2. The standard enthalpy of formation of atomic oxygen is: $\frac{1}{2}O_2(g) \rightarrow O(g)$

must break O_2 bond to become O.

A. Negative, since all spontaneous reactions are exothermic
B. Zero, since oxygen is an element
C. Positive, since breaking of bonds is always endothermic
D. Negative, zero, or positive depending on the temperature
E. Zero, since oxygen is an element and Positive, since breaking of bonds is always endothermic

3. Given the following standard enthalpies of formation:

Compound	ΔH_f (kJ/mol)
$CH_4(g)$	-75
$CO_2(g)$	-394
$H_2O(g)$	-242

What is the standard enthalpy change for the combustion of methane:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

A. +561 kJ
B. -561 kJ
C. +803 kJ
D. -803 kJ
E. -711 kJ

$\Delta H_f = \sum n \cdot \Delta H_f\,prod - \sum n\,\Delta H_f\,react$

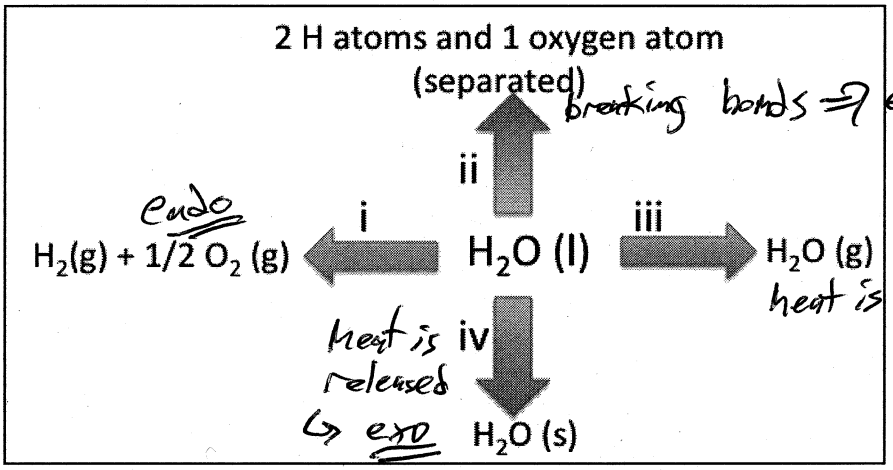
$\Delta H_f = 2\Delta H_{H_2O} + \Delta H_{CO_2} - [2\Delta H_{O_2} + \Delta H_{CH_4}]$

$\Delta H_f = 2mol(-242\,kJ/mol) + -394\,kJ - [0 + -75\,kJ]$

$\Delta H = -803\,kJ$

4. The standard enthalpy of formation for $H_2O(l)$ is $\Delta H = -285$ kJ/mol.

Beginning with H_2O (l), which of the following physical and/or chemical changes is/are **exothermic**?



A. only i
B. i, ii & iii
C. ii & iv
D. only ii
E. only iv

5. Which of the following are **NOT** correctly written as a standard enthalpy of formation reactions?

i) $Mg(s) + O_2(g) + H_2(g) \rightarrow Mg(OH)_2(s)$ $\Delta H = -924.7$ kJ/mol
ii) $H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(l)$ $\Delta H = -285.8$ kJ/mol
iii) $Mg(s) + 2H_2O(l) \rightarrow Mg^{2+}(aq) + 2\ OH^-(aq) + H_2(g)$ $\Delta H = -704.7$ kJ/mol
iv) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ $\Delta H = -124.1$ kJ/mol

A. i & ii
B. iii & iv
C. ii, iii & iv
D. i & iv
E. all are correct

6. 100 mL of water, 100 mL of alcohol, and 200 mL of an unknown liquid, all at 25°C, are heated at the **same rate under identical conditions**. After 3 minutes the temperature of the alcohol is 50°C. It took 5 minutes for the water to reach 50°C. It took 6 minutes for the unknown liquid to reach 50°C.

Which statement is TRUE regarding the specific heat, C_s?

A. C_s (water) = C_s (alcohol) ✗
B. C_s (water) > C_s (alcohol)
C. C_s (water) < C_s (unknown) ✗
D. C_s (alcohol) > C_s (unknown) ✗

Twice as much unknown... so 100 mL of unknown would reach 50°C in 3 min, just like the alcohol.

Larger C_s, small change in Temp, also slower change...

$C_{s\ water} > C_{s\ unknown} = C_{s\ alcohol}$

7. What amount of heat energy, kJ, is released in the combustion of 16.0 g of C_3H_6?

$$2\ C_3H_6(g) + 9\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l) \quad \Delta H° = -4120\ kJ$$

A. 581
B. 783
C. 504
D. 624
E. 725

$$16.0\ g\ C_3H_6 \times \frac{1\ mol\ C_3H_6}{42.0\ g} \times \frac{-4120\ kJ}{2\ mol\ C_3H_6} = -784\ kJ$$

↑ heat is released

∴ 784 kJ are released

8. Which of these will lead to the greatest increase in temperature when added to 100.0 mL of water at 25°C?

A. 94 g of gold at 150°C, specific heat = 0.128 J/g K.
B. 50 g of iron at 110°C, specific heat = 0.452 J/g K.
C. 66 g of silver at 124°C, specific heat = 0.234 J/g K.
D. 70 g of copper at 150°C, specific heat = 0.385 J/g K.

$q = m \times SH \times \Delta T$

9. Given the following equations and ΔH° values, determine the heat of reaction (kJ) at 298 K for the reaction:

$$2\ NF_3(g) + Cu(s) \rightarrow N_2F_4(g) + CuF_2(s)$$

		ΔH° (kJ)
(1)	$2\ NF_3(g) + 2\ NO(g) \rightarrow N_2F_4(g) + 2\ NOF(g)$	-82.9
(2)	$NO(g) + \frac{1}{2}F_2(g) \rightarrow NOF(g)$	-156.9
(3)	$Cu(s) + F_2(g) \rightarrow CuF_2(g)$	-531.0

A. +770.8
B. -605.0
C. -300.1
D. +291.2
E. -291.6

(3) $Cu(s) + F_2(g) \rightarrow CuF_2(g)$ $\Delta H° = -531.0$ kJ

(1) $2NF_3(g) + 2NO(g) \rightarrow N_2F_4(g) + 2NOF(g)$ -82.9

Rev (2) ×2 $2NOF(g) \rightarrow 2NO(g) + F_2(g)$ $+313.8$ kJ

$2NF_3(g) + Cu(s) \rightarrow CuF_2(g) + N_2F_4(g)$ $\Delta H = -300.1$ kJ

10. A volume of 50.0 mL of 0.400 M NaOH(aq) was added to 20.0 mL of 0.500 M H_2SO_4(aq) in a calorimeter of heat capacity 39.0 JK^{-1}. The temperature of the resulting solution rose by 3.60°C. What is the total heat produced (in kJ) in this neutralization? Assume that the specific heat capacity of the neutralized solution is 4.18 $JK^{-1}g^{-1}$.

$$H_2SO_4(aq) + 2\ NaOH(aq) \rightarrow 2\ Na_2SO_4(aq) + H_2O(l)$$

Full Credit Given for all answers

A. -102
B. -111
C. -119
D. -126
E. -132

11. In the introduction to Chapter 6 I played several clips from the hit TV show "The Big Bang Theory" in class. In this episode, Dr. Sheldon Cooper is trying to visualize the behavior of electrons traveling through a graphene sheet. Which of the following statements is/are true regarding his findings?

i) Sheldon's model of the behavior of electrons failed with lima beans, peas, and marbles, but he was able to come up with an accurate model with balls from a ball pit after he determined the proper size ratio with bigger carbon atoms. ✗
ii) Just like Dalton, Thompson, and Bohr, it was relatively easy for Sheldon to develop an accurate model of the behavior of an electron. ✗
iii) Sheldon's model of the behavior of electrons failed with lima beans, peas, and marbles, but he was able to come up with an accurate model after recognizing the electron behaved as both a particle and a wave. ✓

A. ii only
B. iii only
C. i & ii
D. i & iii
E. ii & iii

12. What is the energy of the photons emitted from the He-Ne laser, wavelength = 655 nm?

A. $2.27\ 10^{-19}$ J
B. $4.34\ 10^{-40}$ J
C. $3.03\ 10^{-19}$ J
D. $1.01\ 10^{-27}$ J
E. $5.29\ 10^{-18}$ J

$$\mathcal{E} = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\ \text{J}\cdot\text{s}\ (3.00\times10^{8}\ \text{m/s})}{655\times10^{-9}\ \text{m}}$$

$$\mathcal{E} = 3.03\times10^{-19}\ \text{J}$$

13. Which emission line in the hydrogen spectrum occurs at highest frequency?

A. n = 3 to n = 1
B. n = 1 to n = 3 ✗ Abs
C. n = 4 to n = 2
D. n = 2 to n = 4 ✗ Abs
E. n = 5 to n = 7 ✗ Abs

$$\mathcal{E} = -2.18\times10^{-18}\text{J}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

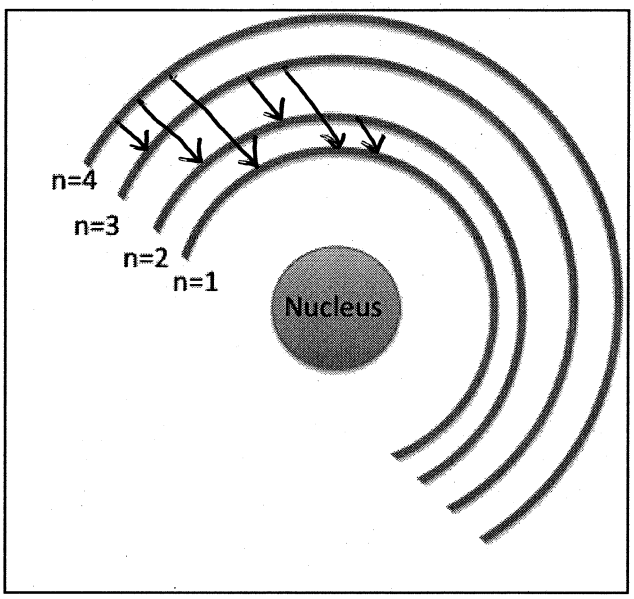
$\mathcal{E} \propto \nu$

largest frequency $\Rightarrow$ largest $\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

A. $\left(1 - \frac{1}{2}\right)$ ← largest

C. $\left(\frac{1}{2} - \frac{1}{4}\right)$

14.



6 spectral emission lines

$n=4 \rightarrow n=3$

$n=4 \rightarrow n=2$

$n=4 \rightarrow n=1$

$n=3 \rightarrow n=2$

$n=3 \rightarrow n=1$

$n=2 \rightarrow n=1$

Suppose a certain atom has four energy levels, and assume all transitions between levels are possible. Which statement is TRUE?

A. The lowest energy light is emitted for n=3 → n = 1 ✗
B. The longest wavelength light is emitted for n = 4 → n = 2 ✗
C. The potential energy is greatest when the electron is at the n=1 level. ✗
D. There are a total of 6 spectral emission lines.
E. There are a total of 4 spectral emission lines. ✗

15. Sodium metal requires a photon with a minimum energy of 4.41×10^{-19} J to emit electrons. Suppose you have two lasers, one emitting light with a wavelength of 210 nm and the other emitting light with a wavelength of 335 nm. Each laser produces 10,000 photons/sec.

Which statement is true regarding the removal of electrons from the metal's surface?

A. Both lasers eject electrons from the metal surface at the same rate.
B. Both lasers eject electrons from the metal surface, but the weaker laser needs to operate for a longer period of time.
C. ✗ Only the laser with photons of 335 nm ejects electrons.
D. ✗ Only the laser with photons of 210 nm ejects electrons.
E. ✗ Neither laser will eject electrons.

$$E = \frac{hc}{\lambda} = 4.41\times10^{-19}\,J \Rightarrow \lambda = \frac{6.626\times10^{-34}\,J\cdot s\,(3.00\times10^{8}\,m/s)}{4.41\times10^{-19}\,J}$$

$\lambda = 451$ nm

$\therefore$ λ of 451 nm or shorter will eject e^-

4d 3s 1 radial node

4d $\ell = 2 \Rightarrow$ 2 angular nodes

16. Which of the following statements best describes a $4d_{xz}$ atomic orbital?

A. The $4d_{xz}$ orbital has the same number of radial and angular nodes.
B. The $4d_{xz}$ orbital has more radial nodes than angular nodes.
C. The $4d_{xz}$ orbital has more angular nodes than radial nodes.
D. The $4d_{xz}$ orbital does not have any radial nodes.
E. The $4d_{xz}$ orbital does not have any angular nodes.

17. Which of the following electron configurations is correct for mercury (Hg)?

A. [Kr] $6s^2 6f^{14} 6d^{10}$
B. [Xe] $4s^2 5f^{14} 6d^{10}$
C. [Xe] $6s^2 4f^{14} 6d^{10}$
D. [Xe] $6s^2 5d^{10}$
E. [Xe] $6s^2 4f^{14} 5d^{10}$

18. How many electrons in a zinc atom have the quantum number $m_l = 0$?

A. 6
B. 8
C. 10
D. 14
E. 30

Zn: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$ (2) (2) (2) (2) (2) (2) (2)

19. Which response correctly fills in the blanks?

The atom _____ has _____ core electrons, _____ valence electrons, and _____ unpaired electrons.

A. oxygen, 2, 6,
B. chlorine,
C. nitrogen, 2, 5, 3
D. neon, 2, 8,
E. fluorine, 2, 7, 5

1s 2s 2p 3s 3p

O: 2 core, 6 valence, 2 unpaired
Cl: 10 core, 7 val, 1 unp.
N: 2 core, 5 val, 3 unp.
Ne: 2 core, 8 val 0 unp.
F: 2 core 7 val, 1 unp.

20. Which of the following sets of quantum numbers could describe one of the valence electrons in a sulfur atom in the ground state?

S: [Ne] $3s^2 3p^4$

$n = 3$

$\ell = 0$ or $\ell = 1$

A. $n=1$ $l=0$ $m_l=0$ $m_s=+½$
B. $n=2$ $l=1$ $m_l=-1$ $m_s=-½$
C. $n=3$ $l=1$ $m_l=0$ $m_s=+½$
D. $n=3$ $l=3$ $m_l=-2$ $m_s=+½$
E. $n=4$ $l=0$ $m_l=-1$ $m_s=+½$

21. The attraction of the nucleus on the outermost electron in an atom tends to:

A. decrease moving from left to right and top to bottom on the periodic table.
B. decrease moving from right to left and top to bottom on the periodic table.
C. decrease moving from left to right and bottom to top on the periodic table.
D. decrease moving from right to left and bottom to top of the periodic table.
E. the attraction of the nucleus to the outermost electron remains constant for each element on the periodic table.

22. Lithium's first and second ionization energies are 519 kJ/mol and 7300 kJ/mol, respectively. Element X has a first ionization energy of 590 kJ/mol and a second ionization energy of 1150 kJ/mol. Element X is most likely to be:

A. Oxygen
B. Sodium
C. Calcium
D. Xenon
E. Fluorine

23. Which of the following is correctly ordered in terms of atomic radius, from smallest to largest?

A. $Mg^{2+} < Na^{+} < F^{-}$
B. $Mg^{2+} < F^{-} < Na^{+}$
C. $F^{-} < Na^{+} < Mg^{2+}$
D. $F^{-} < Mg^{2+} < Na^{+}$
E. $Na^{+} < F^{-} < Mg^{2+}$

24. Arrange the following in order of increasing electron affinity: Cl, P, S, Ar.

A.	Most positive EA	Cl < S < P < Ar	Most negative EA
B.	Most positive EA	Ar < Cl < S < P	Most negative EA
C.	Most positive EA	P < S < Cl < Ar	Most negative EA
D.	Most positive EA	Ar < P < S < Cl	Most negative EA
E.	Most positive EA	Cl < Ar < P < S	Most negative EA

25. Which of the following statements is TRUE?

A. The first ionization potential of H is greater than that of He.
B. The ionic radius of Fe^{+} is larger than that of Fe^{3+}.
C. The electron affinity of C is greater than that of Cl.
D. The atomic radius of Li is larger than that of Cs.
E. All are false.