Term Test 1: CHEM 1E03

1. Which of the following statements are **TRUE**?

i. (i) 1 mole of KNO_3 has a larger mass than 1 mole of $NaNO_3$.

ii. (ii) 10 L of N_2 has lower mass than 9 L of F_2, if both gases are at 300 K and 1 bar pressure.

iii. (iii) 10 g of gold has more atoms than 10 g of lead.

A. i, ii, iii
B. i, iii
C. i
D. ii
E. ii, iii

1. A

All three statements are correct. (i) K+ has a higher atomic weight than Na+, thus potassium nitrate has larger mass in a given mole of salt. (ii) N_2 has a lower molecular weight than F_2 and (iii) gold has lower atomic weight than Pb, thus equivalent mass of Au has fewer number of atoms than Pb since moles = mass [g]/molecular weight

2. How many **moles of ions** – both cations and anions – are present in solution when 0.75 mol of calcium chloride is dissolved in 0.25 L of distilled water?

A. 0.75
B. 3.00
C. 1.50
D. 0.80
E. 2.25

2. E

$CaCl_2$ (s) → Ca^{2+} (aq) + 2 Cl^- (aq) [Dissolution of strong electrolyte/ionic salt – note stoichiometry of balanced reaction]
0.75 mol [$CaCl_2$] = 0.75 mol [Ca^{2+}] + 2 x 0.75 mol [Cl^-] → 2.25 mol total of ions in solution

3. What is the **correct chemical formula** for potassium hydrogen sulfite?

A. $KHSO_4$
B. $KHSO_3$
C. K_2SO_3
D. K_2HSO_4
E. $PHSO_4$

3. B

Potassium Hydrogen Sulfite is $KHSO_3$ [Note this salt dissolves in solution into K^+ (aq) + HSO_3^- (aq)]

4. One of the most potent carcinogens (found in air particulate, cigarette smoke and grilled food) is benzo[*a*]pyrene (molar mass = 252.30 g/mol). Combustion analysis finds that it is 95.21 mass % C and 4.79 mass % H. Which is the **correct molecular formula**?

A. $C_{19}H_{18}$
B. $C_{22}H_{16}$
C. $C_{20}H_{14}$
D. $C_{18}H_{12}$
E. $C_{20}H_{12}$

4. E

As organic aromatic hydrocarbon, this toxic molecule only contains C and H in molecular formula:

For C, if 100 g and determine moles → 95.21 mass% x 100 g = 95.21 g / 12.011 g/mol = 7.93 mol

For H, if 100 g and determine moles → 4.79 mass% x 100 g = 4.79 g / 1.008 g/mol = 4.75 mol

Divide by lowest mole for empirical formula → Nearest whole number consistent with molar mass for molecular formula → C [1.67] and H [1.00] x 12 = $C_{20}H_{12}$

Check → C: 20 x 12.011 g/mol = 240.22 g/mol + H: 12 x 1.008 g/mol = 12.096 g/mol = 252.32 g/mol

5. The anion $^{33}S^-$ contains

A. 17 neutrons, 16 protons, 17 electrons
B. 16 neutrons, 17 protons, 18 electrons
C. 17 neutrons, 17 protons, 16 electrons
D. 33 neutrons, 16 protons, 17 electrons
E. 33 neutrons, 17 protons, 18 electrons

5. A

Mass number = 33 → 33 protons + neutrons
S as element as an atomic number of 16 → 16 protons
Thus it has 33 – 16 = 17 neutrons
Since it is a single charged ion → 17 electrons (1 in excess of protons in nucleus)

6. A sample weighing 0.6760 g that contains an unknown amount of Ba^{2+} ions was completely dissolved in water and treated with an excess of sodium sulfate, Na_2SO_4. A precipitate of $BaSO_4$ formed which was dried and weighed, yielding 0.4105 g. What is the **mass percentage** of barium in the original sample?

A. 58.83
B. 24.15
C. 35.73
D. 69.78
E. 39.77

6. C

Precipitation reaction to isolate dissolved barium: Ba^{2+} (aq)+ SO_4^{2-} (aq) → $BaSO_4$ (s)
Molar mass of $BaSO_4$ = 137.327 g/mol + 32.06 g/mol + 15.999 g/mol x 4 = 233.383 g/mol
Moles of Ba^{2+} = moles of $BaSO_4$ → 0.4105 g /233.383 g/mol = 0.001759 mol
Mass of Ba^{2+} = 0.001759 mol x 137.327 g/mol = 0.2415 g
Mass% of Ba^{2+} in unknown sample = 0.2415 g/0.6760 g x 100 = 35.73%

7. What is the correct **ordering** of the following elements, according to **increasing atomic radius**? Rb, Ne, Sr, Si, Ge, N

A) Ne < N < Si < Ge < Sr < Rb
B) Ne < N < Ge < Si < Sr < Rb
C) Ne < Sr < Si < Rb < N < Ge
D) N < Ne < Si < Ge < Rb < Sr
E) N < Ne < Ge < Si < Rb < Sr

7. A
Ne is smallest atom (2^{nd} period/Group 18) and Rb is largest atom (5^{th} period/Group 1) → Only A or B is correct → However, Ge > Si → Thus, only A is correct

8. Which of the following orderings are **CORRECT**, according to **increasing ionic** or **atomic radius**?

(i) $Rb^{+} < Sr^{2+} < Se^{2-} < Br^{-}$

(ii) $N^{-} < N^{2-} < N^{3-}$

(iii) Cl < As < Se < In

A) ii, iii
B) i, iii
C) i, ii
D) i, ii, iii
E) ii

8. E

Only ii) is correct since atomic radius increases with added valence electrons to N (same atomic number). As > Se (iii) incorrect, and $Se^{2-} > Br^{-}$ (i) incorrect

9. Which of the following statements are **TRUE**?

(i) The first ionization energy of nitrogen is higher than that of oxygen.

(ii) The first ionization energy of oxygen is higher than that of fluorine.

(iii) $N(g) + e^{-} \rightarrow N^{-}(g)$ has a positive change in energy.

(iv) $O(g) + e^{-} \rightarrow O^{-}(g)$ has a positive change in energy.

A) i, iii
B) i, ii
C) ii, iii, iv
D) i, ii, iv
E) ii, iv

9. A

i) True due to unusual stability of N as a result of half full valence shell.
ii) False, higher ionization energy for F due to smaller atomic radius
iii) True, since electron affinity is unfavorable as it alters half-full valence shell
iv) False, as O has a negative (release of energy) electron affinity

10. Which of the following orderings is/are **CORRECT**, according to **increasing magnitude of electron affinity**?

(i) Si < S < Cl

(ii) Ge < As < Br

(iii) Ca < K < Ge

A) ii, iii
B) i, ii
C) ii
D) i, ii, iii
E) i, iii

10. E
i) Correct: Increase in electron affinity across period 2
ii) Incorrect: As has half-full valence shell → lower magnitude of electron affinity than Ge
iii) Correct: As Ca has full valence shell, it has lower magnitude of electron affinity than K

11. Which of the following statements are **TRUE**?

(i) CO_2 is a more acidic oxide than N_2O_5 .

(ii) As is more electronegative than Ge.

(iii) BaO is a basic oxide.

A) i, ii, iii
B) i, ii
C) ii
D) ii, iii
E) i, iii

11. D

i) False: N_2O_5 produces a strong acidic, HNO_3 (nitric acid)
ii) True: As is more electronegative than Ge
iii) True: Ba is group 2 alkaline earth metal forming $Ba(OH)_2$

12. Which of the following statements are **TRUE**?

(i) Second ionization energy (I_2) is greater than first ionization energy (I_1), for all elements.

(ii) Lithium (Li) has a higher second ionization energy than berylium (Be).

(iii) All ionization energies are positive.

A) i, ii
B) i, ii, iii
C) ii
D) ii, iii
E) i, iii

12. B

All statements are true in this questions. Second ionization energy is always greater than first ionization energy, Li has higher second ionization energy than Be, and all ionization energies are positive (energy input to ionize electron)

13. Which one of the following statements is **FALSE**?

A. The ground state electron configuration of an oxygen atom has two unpaired electrons.
B. O^{2-} is larger than F^{-}.
C. Be has a larger ionization energy than Li.
D. Al has a larger ionization energy than B.
E. Be is smaller than Li.

13. D

D is false since Al has a lower ionization energy than B since valence electron is located farther away from nucleus. All other statements are true.

14. A sample of hydrogen atoms have their electrons excited to various energy levels; this is followed by emission of light. Which one of the following emission transitions produces a photon with the **shortest wavelength**?

A. n = 2 n = 1
B. n = 3 n = 2
C. n = 7 n = 6
D. n = 5 n = 2
E. n = 7 n = 1

14. E

Shortest wavelength of light emitted from excited H atom corresponds to relaxation of electron involving the largest gap in energy → n=7 → n=1

15. Which one of the following represents the electron configuration of an **excited oxygen atom**?

A. $ls^2\ 2s^2\ 2p^3\ 3s^1$
B. $1s^2\ 2s^2\ 2p^5$
C. $ls^2\ 2s^2\ 2p^4$
D. $ls^2\ 2s^1\ 2p^3\ 3s^1$
E. $ls^2\ 2s^0\ 2p^3\ 3s^2$

15. A

A is correct → 1 valence electron ([Ne]$2p^4$ is ground state) is excited from 2p → 3s state.

16. A detector receives a signal consisting of green light, with a wavelength of 540 nm. The total energy of the signal is 2.50×10^{-14} J. **How many photons** reach the detector?

A. 1.48×10^4
B. 6.80×10^7
C. 6.80×10^4
D. 2.10×10^{-5}
E. 1.48×10^7

16. C

$\nu = c/\lambda = 3.00 \times 10^8$ m/s / $5.40 \times 10^{-7} = 5.555 \times 10^{14}$ Hz

E (photon) $= h\nu = 6.626 \times 10^{-34}$ Js X 5.555×10^{14} $s^{-1} = 3.681 \times 10^{-19}$ J/photon

If total $E = 2.50 \times 10^{-14}$ J, # of photons $= 2.50 \times 10^{-14}$ J / 3.681×10^{-19} J/photon $= 6.79 \times 10^4$ photons

17. Identify the **FALSE** statement(s):
(i) (3, 2 , −1, −1/2) is an allowed set of (n, ℓ, m_ℓ, m_s) quantum numbers for a **3p** electron.
(ii) The ground-state electron configuration of the sulfide anion (S^{2-}) has two **unpaired** electrons.
(iii) On average, a 3p electron is **further away** from the nucleus than a 3s electron.
(iv) The ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$) electron configuration represents the ground state of the **Si^+ cation**.
(v) An iron atom in its ground state is **paramagnetic** – i.e., it has unpaired electrons.

A. i, iv
B. i , ii
C. ii, iii
D. iv, v
E. v

17. B

i) This statement is false since 3p orbital must have l = 1 (not 2 → d orbital)
All other statements are true
ii) this statement is false as S^{2-} is isoelectronic with the noble gas meaning the valence shell has a full octet of electrons

18. It takes 492 kJ of energy to remove one mole of electrons from the atoms on the surface of solid gold. What is the **maximum wavelength (in nm)** of light capable of doing this?

A. 123
B. 243
C. 404
D. 743
E. 817

18. B

Threshold energy for removing 1 mole of photoelectrons from gold metal surface = 492 kJ/mol

*E (photon) = hc/λ → λ= hc / E = (6.626 x 10^{-34} Js x 3.00 E8 m/s)*6.022 x 10^{23} mol/4.92 x 10^5 J/mol = 2.433 x 10^{-7} m or 243 nm*

19. What is the **maximum number of electrons** that can be associated with the set of quantum numbers n = 3, ℓ = 2, m_ℓ = −2?

A. 3

B. 1
C. 0
D. 2
E. undetermined

19. D

n=3, l=2, ml = -2 → equivalent to one of five 3d orbitals → Each subshell can only fill a maximum 2 e- (spins are paired – Pauli exclusion principle).

20. From the Cl-Cl bond energy (243 kJ mol^{-1}), calculate the **minimum frequency** of light (in Hz or s^{-1}) which will dissociate a Cl_2 molecule into Cl atoms.

A. 3.67×10^{38}
B. 7.63×10^{-38}
C. 9.06×10^{15}
D. -5.62×10^{-19}
E. 6.09×10^{14}

20. E

E (photon) = hν →

ν = E/h = (2.43 x 10^5 J/mol /6.022 x 10^{23} mol-1)/6.626 x 10^{-34} Js = 6.09 x 10^{14} Hz (s^{-1})