

STUDENT ID NUMBER :.....



UNIVERSITY OF GHANA

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BSC. ENGINEERING

FIRST SEMESTER EXAMINATIONS: 2018/2019

SCHOOL OF ENGINEERING SCIENCES

FAEN 107: GENERAL CHEMISTRY (3 CREDITS)

INSTRUCTIONS:

ANSWER ALL QUESTION IN SECTION A (OBJECTIVE SETS) AND SECTION B

ANSWER SECTIONS A ON THE QUESTION PAPER AND SECTION B IN THE ANSWER BOOKLET PROVIDED

TIME ALLOWED: TWO AND HALF ($2 \frac{1}{2}$) HOURS

SECTION A: OBJECTIVE & FILL-IN SETS [40 MARKS]

CIRCLE/FILL-IN THE CORRECT ANSWER(S) ON THE QUESTION PAPER AND MAKE SURE YOU WRITE YOUR STUDENT ID NUMBER ON THE TOP LEFT CORNER OF YOUR QUESTION PAPER

1. Which of the following statements is true?

- The krypton 1s orbital is smaller than the helium 1s orbital because krypton's *p* and *d* orbitals crowd the *s* orbitals.
- The krypton 1s orbital is larger than the helium 1s orbital because krypton contains more electrons.
- The krypton 1s orbital is smaller than the helium 1s orbital because krypton's nuclear charge draws the electrons closer.
- The krypton 1s orbital and helium 1s orbital are the same size because both *s* orbitals can only have two electrons.
- The krypton 1s orbital is larger than the helium 1s orbital because krypton's ionization energy is lower so it's easier to remove electrons.

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2. Which of the following is ranked in order of **largest to smallest** atomic radius?

- a. $\text{Rb} > \text{Mn} > \text{As} > \text{S} > \text{O}$
- b. $\text{Mn} > \text{Rb} > \text{O} > \text{S} > \text{As}$
- c. $\text{O} > \text{S} > \text{As} > \text{Mn} > \text{Rb}$
- d. $\text{Rb} > \text{As} > \text{Mn} > \text{O} > \text{S}$
- e. $\text{Rb} > \text{Mn} > \text{S} > \text{As} > \text{O}$

3. Which of the following atoms has the highest ionization energy?

- a. F
- b. Be
- c. N
- d. C
- e. Li

4. Which of the following atoms has the smallest atomic radius?

- a. As
- b. Sb
- c. Bi
- d. P
- e. N

5. Rank the following from **smallest to largest** atomic radius.

- a. O, Zn, Ca, Ba
- b. O, Ca, Zn, Ba
- c. Ba, Ca, Zn, O
- d. O, Zn, Ba, Ca
- e. Ca, Ba, Zn, O

6. Which of the following has the smallest atomic radius?

- a. N
- b. F
- c. Br
- d. Cl
- e. S

7. Which of the following atoms has the highest ionization energy?

- a. Al
- b. Si
- c. P
- d. As
- e. Sb

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8. Which of the following statements is correct **and** provides the best explanation for what happens when the first two electrons are removed from calcium?

- a. Energy is released when either electron comes off since calcium is a metal and not very electronegative.
- b. It takes less energy to remove the second electron from calcium as compared to the first because calcium wants to have eight electrons in its outer shell (and thus have a noble gas configuration).
- c. It takes less energy to remove the first electron as compared to the second because it is in a higher energy level than the second electron.
- d. It takes more energy to remove the second electron as compared to the first because the nucleus binds the electrons more tightly as each electron is removed.
- e. Electrons cannot be removed from calcium since it is a metal and only wants to gain electrons to become more stable.

9. Which of the following exhibits the correct orders for both atomic radius and ionization energy, respectively?

- a. S, O, F, and F, O, S
- b. F, S, O, and O, S, F
- c. S, F, O, and S, F, O
- d. F, O, S, and S, O, F
- e. none of these

10. Which of the atoms in Group 4A has the highest ionization energy?

- a. C
- b. Ge
- c. Sn
- d. Si
- e. Pb

11. Order the elements Si, S, and F in terms of increasing ionization energy.

- a. Si, S, F
- b. F, S, Si
- c. F, Si, S
- d. Si, F, S
- e. S, Si, F

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12. Order the elements Te, I, and Br in terms of increasing atomic radius.

a. Br, Te,
I

b. Br, I,
Te

c. Te, I,
Br

d. Te, Br,
I

e. I, Te,
Br

13. Which of the following statements about the periodic table is **false**?

- a. Elements in the same column have similar reactivities because their valence electrons tend to be located in the same types of orbitals.
- b. A series of ions that are isoelectronic must have the same electron configuration.
- c. The atomic size of the elements increases going across a period from left to right because the number of electrons increases, so they are located further from the nucleus.
- d. It takes more energy to remove an electron from lithium than from cesium because the valence electrons in lithium are located closer to the nucleus.
- e. Fluorine is the most electronegative element due to its size and nuclear charge.

14. The oxidation state of sulfur in K_2SO_3 is

- a. +4
- b. +6
- c. +2
- d. -2
- e. 0

15. An atom has a valence shell electron configuration of $ns^2 np^5$. To which group of metals in the periodic table does it belong?

- a. alkali metals
- b. alkaline earth metals
- c. halogens
- d. noble gases
- e. inner transition metals

16. Which electron configuration is impossible?

- a. $1s^2 2s^2 2p^6 3s^2$
- b. $1s^2 2s^2 2p^6 3s^2 3p^5$
- c. $1s^2 2s^2 2p^6 3s^2 3s^5 4s^1$
- d. $1s^2 2s^2 2p^6 2d^2$
- e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

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17. Which electron configuration represents an excited state?

- a. $1s^2 2s^2 2p^6 3s^2$ b. $1s^2 2s^2 2p^6 3s^2 3p^5$
c. $1s^2 2s^2 2p^6 3s^2 3s^5 4s^1$ d. $1s^2 2s^2 2p^6 2d^2$
e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

18. What is the electron configuration of a chromium atom?

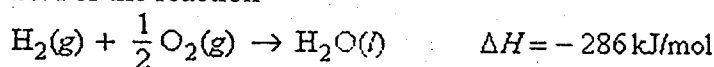
- a. $[\text{Ar}]4s^1 3d^5$ b. $[\text{Ar}]4s^2 3d^4$
c. $[\text{Ar}]3d^6$ d. $[\text{Ar}]4s^2 1d^4$
e. $[\text{Ar}]4s^1 4d^5$

19. Determine the enthalpy change when 19.39 g of carbon is reacted with oxygen according to the reaction:



- a. 636.43 kJ
b. 7.64×10^3 kJ
c. -636.43 kJ
d. -7.64 kJ
e. 6.75 kJ

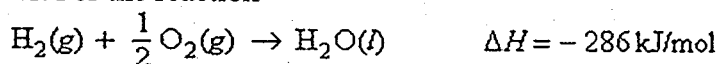
20. For the reaction



Calculate the enthalpy change when 4.73 g of hydrogen gas is reacted with excess oxygen.

- a. -60.46 kJ
b. 671.02 kJ
c. -671.02 kJ
d. 1.35×10^3 kJ
e. -1.35×10^3 kJ

21. For the reaction

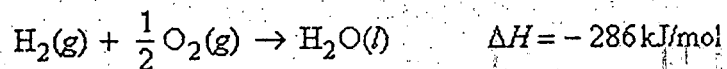


What is the enthalpy change when 15 mol of hydrogen gas reacts with excess oxygen.

- a. 19.06 kJ
b. -19.06 kJ
c. 5.24×10^{-2} J
d. -4.29×10^3 J
e. -2.12×10^3 J

22. For the reaction

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Calculate the enthalpy change when 2.79 g of water is produced.

- a. 102.14 kJ
- b. 800.79 kJ
- c. -800.79 kJ
- d. 44.44 kJ
- e. -44.44 kJ

23. A 100.0 g sample of water at 27.0°C is poured into a 77.40 g sample of water at 89.0°C. What will be the final temperature of the water?

- a. 88.70°C
- b. 424.27°C
- c. 23.61°C
- d. 185.33°C
- e. 54.05°C

24. A 51.10 g sample of aluminum at 95.0°C is dropped into 35.0 g of water at 40.0°C. What is the final temperature of the mixture? (specific heat capacity of aluminum = 0.89 J/g°C; specific heat capacity of water = 4.184 J/g°C)

- a. 53.03°C
- b. -8.00°C
- c. 100.81°C
- d. 23.54°C
- e. -15.22°C

25. The specific heat capacity of gold is 0.13 J/g°C. How many calories of energy are needed to warm 0.569 g of gold from 30.0°C to 39.5°C?

- a. 0.70 cal
- b. 0.16 cal
- c. 1.23 cal
- d. 2.94 cal
- e. 22.65 cal

26. 561.20 J of heat was added to 8.00 g of water. The final temperature of the water was measured to be 64.2°C. What was the initial temperature of the water? (specific heat capacity of water = 4.184 J/g°C)

- a. -80.96°C
- b. 80.96°C
- c. 47.43°C
- d. 3.61°C
- e. -5.95°C

27. Which of the following processes is endothermic?

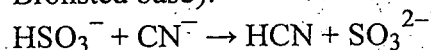
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- a. water droplets condensing on a soda can on a hot summer day
 - b. an ice pack getting cold (due to ammonium nitrate dissolving in water inside the pack)
 - c. thermite reaction between iron(III) oxide and aluminum (spectacular flames are observed)
 - d. freezing water to make ice cubes
 - e. none of the above are endothermic processes
28. Which of the following statements about energy is **false**?
- a. A reaction cannot be exothermic overall if activation energy is required.
 - b. A system is the most stable when it is at its lowest energy state.
 - c. Energy can be defined as whatever is required to oppose a natural tendency.
 - d. Energy transferred into a system can also be transferred out of the system.
 - e. An atom in an excited state can return to its ground state by releasing visible light.
29. Which of the following processes is exothermic?
- a. rolling a ball up a hill
 - b. boiling water in a beaker to make steam
 - c. allowing meat to thaw after taking it out of the freezer
 - d. reacting hydrogen and oxygen gases to make water
 - e. a popsicle melting on a warm summer day
30. As water is heated, its $[H^+]$ increases. This means that
- a. the water is no longer neutral
 - b. $[H^+] > [OH^-]$
 - c. $[OH^-] > [H^+]$
 - d. a and b are correct
 - e. none of these
31. Which of the following is a conjugate acid-base pair?
- a. HNO_3^- , H_2NO_3
 - b. HNH_4 , NH_4^+
 - c. H_2F , HF^-
 - d. HPO_4^{2-} , PO_4^{3-}
 - e. H_2CN , CN^-
32. Choose the case that is **not** a Bronsted conjugate acid-base pair.

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- a. CH_3NH_3^+ , CH_3NH_2
- b. HCN , CN^-
- c. HClO_2 , ClO_2^-
- d. HCO_2H , HCOH
- e. H_3BO_3 , H_2BO_3^-

33. Identify the Bronsted acids and bases in the following equation (A = Bronsted acid, B = Bronsted base):



- a. B A B A
- b. B B A A
- c. A B A B
- d. A B B A
- e. B A A B

34. Consider the reaction $\text{HC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$. Which species is the conjugate acid?

- a. $\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$
- b. $\text{H}_2\text{O}(\text{l})$
- c. $\text{H}_3\text{O}^+(\text{aq})$
- d. $\text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$
- e. two of these

35. Which of the following is **not** a conjugate acid-base pair?

- a. H_2SO_4 , SO_4^{2-}
- b. HNO_3 , NO_3^-
- c. $\text{HC}_2\text{H}_3\text{O}_2$, $\text{C}_2\text{H}_3\text{O}_2^-$
- d. H_2PO_4^- , HPO_4^{2-}
- e. HBr , Br^-

36. How many moles of pure NaOH must be used to prepare 1.0 L of a solution that has $\text{pH} = 12.26$?

- a. 8.15×10^{-16} mol
- b. 0.01 mol
- c. 5.49×10^{-13} mol
- d. 1.74 mol
- e. none of these

37. Calculate the pH of a 0.04499 M HCl solution.

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- a. 1.22
- b. 1.34
- c. 12.65
- d. 12.29
- e. none of these

38. Which statement is true for a strong base solution with a concentration greater than 1.0 M?

- a. $\text{pOH} > \text{pH}$
- b. $\text{pH} > \text{pOH}$
- c. $\text{pH} < 0$
- d. $\text{pH} < 14$
- e. Two of these (a-d) are true.

39. A solution with a pH of 2 is how many times more acidic as a solution with a pH of 6?

- a. 3.00
- b. 0.33
- c. 100000.00
- d. 10000.00
- e. 8.00

40. Calculate the pH of an acid solution containing 0.04399999999999997 M HNO_3 .

- a. 12.64
- b. 2.80
- c. 1.35
- d. 0.04
- e. none of these

SECTION B

ANSWER ALL QUESTIONS FROM THIS SECTION IN THE ANSWER BOOKLETS PROVIDED

1.

- a. One of the radiographic devices used in a dentist's office emits an X-ray of wavelength 2.090×10^{-11} m. What is the energy, in joules, and frequency of this X-ray?

Speed of Light, $c = 2.998 \times 10^8$ m/s

Planck's constant, $h = 6.626 \times 10^{-34}$ Js

- b. Why is the electron in a Bohr hydrogen atom bound less tightly when it has a quantum number of three (3) than when it has a quantum number of one (1) ?
- c. What does it mean to say that the energy of the electrons in an atom is quantized?
- d. The melting of ice at room temperature is an endothermic process. Explain why this occurs?
- e. Provide for the set of quantum numbers for each of the electrons with an n of 4 in a Se atom in Table 1 below.

Table 1. Fill in the empty columns for the quantum numbers

n	l	m_l	s
4			
4			
4			
4			
4			
4			

[20 Marks]

2.

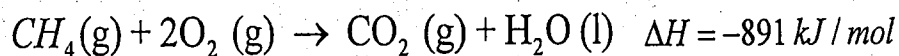
- a. Give the definition of an acid and a base according to;
- Arrhenius
 - Brønsted–Lowry.
 - Write an equation showing how HCl (g) behaves as an Arrhenius acid when dissolved in water. Write an equation showing how NaOH (s) behaves as an Arrhenius base when dissolved in water.
 - Acetic acid is the principal ingredient in vinegar; that's why it tastes sour. At equilibrium, a solution contains $[\text{CH}_3\text{CO}_2\text{H}] = 0.0787 \text{ M}$ and $[\text{H}_3\text{O}^+] = [\text{CH}_3\text{CO}_2^-] = 0.00118 \text{ M}$. What is the value of K_a for acetic acid?
 - Calculate the pH of a $1.5 \times 10^{-11} \text{ M}$ solution of HCl .
- b. How do the components of a conjugate acid–base pair differ from one another? Give an example of a conjugate acid–base pair to illustrate your answer.
- c. Which of the following do *not* represent a conjugate acid–base pair? For those pairs that are not conjugate acid–base pairs, write the correct conjugate acid–base pair for each species in the pair.
- HI, I^-
 - HClO, HClO_2
 - $\text{H}_3\text{PO}_4, \text{PO}_4^{3-}$
 - $\text{H}_2\text{CO}_3, \text{CO}_3^{2-}$

[20 Marks]

3.

- a. In studying heat flows for chemical processes, what do we mean by the terms *system* and *surroundings*?
- b. Are the following processes exothermic or endothermic?
- When solid KBr is dissolved in water, the solution gets colder.
 - Natural gas (CH_4) is burned in a furnace.
 - When concentrated sulfuric acid is added to water, the solution gets very hot.

- iv. Water is boiled in a tea-kettle.
- c. Calculate the enthalpy change when 1.00 g of methane is burned in excess oxygen according to the reaction;



[Atomic Number for; C = 12, H = 1, O = 16]

[20 Marks]

4.

- a. For each of the following oxidation-reduction reactions, identify which element is oxidized and which is reduced.

- i. $6\text{Na}(\text{s}) + \text{N}_2(\text{g}) \rightarrow 2\text{Na}_3\text{N}(\text{s})$
- ii. $\text{Mg}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$
- iii. $2\text{Al}(\text{s}) + 3\text{Br}_2(\text{l}) \rightarrow 2\text{AlBr}_3(\text{s})$
- iv. $\text{CuSO}_4(\text{aq}) + \text{Mg}(\text{s}) \rightarrow \text{MgSO}_4 + \text{Cu}(\text{s})$

- b. Balance each of the following half-reactions.

- i. $\text{Cu}(\text{s}) \rightarrow \text{Cu}^{2+}(\text{aq})$
- ii. $\text{Fe}^{3+}(\text{aq}) \rightarrow \text{Fe}^{2+}(\text{aq})$
- iii. $\text{Br}^-(\text{aq}) \rightarrow \text{Br}_2(\text{l})$
- iv. $\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}(\text{s})$

- c. Balance each of the following half-reactions, which take place in acidic solution.

- i. $\text{SO}_4^{2-}(\text{aq}) \rightarrow \text{H}_2\text{SO}_3(\text{aq})$
- ii. $\text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- iii. $\text{NO}_2^-(\text{aq}) \rightarrow \text{NO}_3^-(\text{aq})$

[20 Marks]