CEM 2EB1/1A2E

SUPPLEMENTARY EXAM

JANUARY 2020

EXAMINERS:	**DR. T. BREDENKAMP, DR. A. ADEYINKA**
MODERATOR:	**DR N. BINGWA**
DATE:	**07/01/2020**
TIME:	**120 min**
MARKS:	**70**

INSTRUCTIONS:

1. This paper consists of 8 pages including a Periodic Table.
2. **WRITE YOUR NAME, SURNAME AND STUDENT NUMBER AND LECTURER'S NAME ON THIS SHEET. ANSWER ALL QUESTIONS IN THE BOOKLET PROVIDED**
3. Calculators are allowed but no cell phones may be used.
4. Use the **<u>correct number of significant figures</u>** when doing calculations.

NAME:____

SURNAME:____

STUDENT NUMBER:___________________________________

LECTURER:____

MULTIPLE CHOICE **[20 MARKS]**

1. Which of the following is false? (1)

   a. Experiments can be used to show that a theory is somewhat limited in scope.
   b. A hypothesis which has successfully withstood many tests eventually can become a theory.
   c. In general, a theory can be proven to be absolutely true.
   d. In general, a theory cannot be proven to be absolutely true.
   e. A theory is an explanation of general principles, which has withstood repeated testing.

2. Which is an example of a physical change? (1)

   a. A piece of paper burns in air with a smoky flame.
   b. The crude metal ore was first heated then combined with pure oxygen gas to make the oxide of the metal.
   c. The chef made scrambled eggs for their breakfast.
   d. Steam from the boiling water condenses on the cooler part of the ceiling.
   e. The table salt in the warehouse was used to make some of the polymeric material.

3. What is the formula for manganese (III) monohydrogen phosphate? (1)

   a. $MnHO_4$ b. $MnHPO_4$
   c. $MnHPO_3$ d. $Mn_2(HPO_4)_3$
   e. Mn_3HPO_4

4. Two elements, Qr and E, combine to form an ionic compound whose formula is QrE_2. Qr also combines with element Z to form an ionic compound, Qr_3Z_2. Based on this information, what is a reasonable value for the charge on E? (Assume that Qr has the same charge in both compounds.) (1)

   a. 1+ b. 2-
   c. 2+ d.1-
   e. 3-

5. Phosphorus tribromide (PBr_3, 270.69 g mol^{-1}) and water (18.015 g mol^{-1}) react to form phosphorous acid (H_3PO_3, 81.996 g mol^{-1}) and hydrogen bromide (80.912 g mol^{-1}). If 0.5000 moles of phosphorus tribromide was reacted with 2.000 moles of water

and 98.048 grams of hydrogen bromide were obtained, what was the percent yield from the reaction? (2)

a. 72.16 %
b. 97.22 %
c. 78.62 %
d. 80.79 %
e. 85.93 %

6. Which statement below is true? (1)

a. All acids are strong electrolytes and ionize completely when dissolved in water.
b. All bases are weak electrolytes and ionize completely when dissolved in water.
c. All bases are strong electrolytes and ionize completely when dissolved in water.
d. All salts are strong electrolytes and dissociate completely if they dissolve in water.
e. All salts are weak electrolytes and ionize partially when dissolved in water.

7. Complete the balancing of the following half-reaction, taking place in basic media,

$$Br^-(aq) \rightarrow BrO_3^-(aq)$$

How many hydroxide ions are needed to balance it? (2)

a. 2 hydroxide ions, on the left side
b. 4 hydroxide ions, on the left side
c. 4 hydroxide ions, on the right side
d. 6 hydroxide ions, on the left side
e. 6 hydroxide ions, on the right side

8. Consider the unbalanced redox equation,

$$C_4H_{10}(l) + Cr_2O_7^{2-}(aq) + H^+(aq) \rightarrow H_6C_4O_4(s) + Cr^{3+}(aq) + H_2O(l)$$

The oxidizing agent is (1)

a. $C_4H_{10}(l)$
b. $Cr_2O_7^{2-}(aq)$
c. $H^+(aq)$
d. $H_6C_4O_4(s)$
e. $Cr^{3+}(aq)$

9. How many unpaired electrons are in gold? (1)

a. 2
b. 1
c. 6
d. 8
e. 4

10. Given the following sets of quantum numbers for *n, l,* m_l*, and* m_s, which one of these sets is not possible for an electron in an atom? (1)

n ***l*** $\boldsymbol{m_l}$ $\boldsymbol{m_s}$

a. 4 2 2 -½

b. 3 1 -1 -1

c. 4 3 2 ½

d. 4 3 -2 -½

e. 5 2 2 ½

11. Which atom has the smallest first ionization energy? (1)

a. Ba

b. Cs

c. C

d. K

e. Mg

12. An open-end mercury manometer was constructed from a U-shaped tube and connected to a gas container. In a particular measurement, the level in the end of the tube connected to the gas container measured 82.8 cm above the U-neck, while the level in the open end (to the atmosphere) was 17.2 cm above the U-neck. The outside air pressure in the laboratory was measured as 764 torr. What is the pressure in the gas container? (2)

a. 159 torr

b. 108 torr

c. 698 torr

d. 830 torr

e. 1420 torr

13. A gas sample occupies a volume of 1.446 L when the temperature is 185.0 ˚C and the pressure is 624 torr. How many molecules are in the sample? (2)

a. 1.90×10^{22}

b. 2.82×10^{22}

c. 4.71×10^{22}

d. 9.10×10^{21}

e. 9.10×10^{22}

14. A sample of a gas occupies a volume of 1.462 liters at 30.00°C and 1.250 atm. It was placed in a different vessel in which the pressure was measured as 722.5 torr when the temperature was 25.20 ˚C. What was the volume of this new vessel? (2)

a. 1.892 liters

b. 0.5285 liters

c. 2.125×10^{-3} liters

d. 1.615 liters

e. 470.7 liters

15. SO_2 can react with OH^-, forming HSO_3^-. In this reaction, (1)

a. the OH^- ion acts as a Lewis base, donating an electron pair to the SO_2 molecule to form a coordinate covalent bond.
b. the SO_2 acts as a Lewis acid, accepting a proton from the OH^- ion.
c. the OH^- ion acts as a Brønsted base, donating a proton to the SO_2 molecule.
d. the SO_2 acts as a Brønsted acid, accepting a proton from the OH^- ion.

e. the OH^- ion acts as a Lewis acid, accepting an electron pair from the SO_2 molecule to form a coordinate covalent bond.

Question 1 **[17 MARKS]**

1.1) Titanium metal can exist as Ti^{2+}, Ti^{3+} and Ti^{4+} ions. Provide the chemical formula and name of the compounds formed from the combination of each of these possible Titanium ions and PO_4^{2-} anion. (6).

1.2) Write the formulas for the following molecules (i) dinitrogen trioxide (ii) disulpur dichloride. (2).

1.3) Solder is an alloy containing the metals tin and lead. A particular sample of this alloy weighing 0.875 g was dissolved in acid. All of the tin was then converted to the +2 oxidation state. Next, it was found that 0.184 g $Na_2Cr_2O_7$ was required to oxidize the Sn^{2+} to Sn^{4+} in an acidic solution. In the reaction, the chromium was reduced to Cr^{3+} ion.

a) Write a balanced net ionic equation for the reaction between Sn^{2+} and Cr_2O_7 in an acidic solution. (3)

b) Calculate the number of grams of tin that were in the sample of solder. (2)

c) What was the percentage by mass of tin in the solder? (2)

d) How many Pb atoms are present in the Solder alloy sample? (2)

Question 2 **[20 MARKS]**

2.1) Suppose you wanted to make an electrical circuit using aqueous solutions to light up a bulb. Which of the following materials will you add to water to make this possible? Explain you reasoning. (3)

10 g Fructose, 10 g sodium chloride, 50 g ethanol or 50 g lead(II)chloride

2.2) How many milligrams of MgI_2 must be added to 250.0 mL of 0.0876 M KI to produce a solution with $[I^-] = 0.1000$ M? (4)

2.3) The molar mass of a certain metal carbonate, MCO_3, can be determined by adding an excess of HCl acid to react with all the carbonate and then "backtitrating" the remaining acid with NaOH. The equations are:

$$MCO_3(s) + 2HCl(aq) \rightarrow MCl_2(aq) + H_2O(l) + CO_2(g)$$
$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

In a certain experiment, 20.00 mL of 0.0800 *M* HCl were added to a 0.1022-g sample of MCO_3. The excess HCl required 5.64 mL of 0.1000 *M* NaOH for neutralization. Calculate the molar mass of the carbonate and identify M. (8)

2.4) In alcohol fermentation, yeast converts glucose to ethanol and carbon dioxide:

$$C_6H_{12}O_6(s) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$$

If 5.97 g of glucose are reacted and 1.44 L of CO_2 gas are collected at 293 K and 0.984 atm, what is the percent yield of the reaction? (5)

Question 3 **[5 MARKS]**

3.1 The frequency of electromagnetic radiation emitted from a hydrogen atom from n = 4 to n_f is 6.17×10^{14} /s. Determine the value of n_f. (5)

Question 4 **[8 MARKS]**

4.1) The compound $Mg(OH)_2$ is basic, but $Si(OH)_4$ is an acid (silicic acid). Explain the reason for this observation. (2)

4.2) Explain why H_2S is a stronger acid than H_2O (2)

4.3) Use Lewis structures to show the Lewis acid-base reaction between NH_2^- and H^+ to give NH_3. Identify the Lewis acid and the Lewis base in the reaction (4)

END OF PAPER

CEM1A2E DATA SHEET

Constants:

R = 0.08206 L atm mol^{-1} K^{-1}

N_A = 6.022 x 10^{23} mol^{-1}

h **= 6.626 x 10^{-34} J.s (Planck's constant)**

R_H = 1.097 x 10^{7} m^{-1}

c **= 3.00 x 10^{8} m.s^{-1}**

$$\Delta E = -hcR_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Activity of metals:

$K \rightarrow K^+ + e^-$

$Na \rightarrow Na^+ + e^-$

$Mg \rightarrow Mg^{2+} + 2e^-$

$Al \rightarrow Al^{3+} + 3e^-$

$Zn \rightarrow Zn^{2+} + 2e^-$

$Cr \rightarrow Cr^{3+} + 3e^-$

$Fe \rightarrow Fe^{2+} + 2e^-$

$Ni \rightarrow Ni^{2+} + 2e^-$

$Sn \rightarrow Sn^{2+} + 2e^-$

$Pb \rightarrow Pb^{2+} + 2e^-$

$H_2 \rightarrow 2H^+ + 2e^-$

$Cu \rightarrow Cu^{2+} + 2e^-$

$Ag \rightarrow Ag^+ + e^-$

$Au \rightarrow Au^{3+} + 3e^-$

Standard temperature and pressure	(STP)
1 standard temperature	0°C
1 standard temperature	273 K
1 standard pressure	1 atm
1 standard pressure	760 torr
1 standard pressure	14.7 psi

PV = nRT
R = 0.08206 L.atm/mol.k
760 mmHg = 760 torr = 1 atm