



CEM 2EB1/1A2E
SUPPLEMENTARY EXAM
JANUARY 2020

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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 correct number of significant figures 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. $\text{Mn}_2(\text{HPO}_4)_3$
 - 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 , $270.69 \text{ g mol}^{-1}$) and water ($18.015 \text{ g mol}^{-1}$) react to form phosphorous acid (H_3PO_3 , $81.996 \text{ g mol}^{-1}$) and hydrogen bromide ($80.912 \text{ g mol}^{-1}$). If 0.5000 moles of phosphorus tribromide was reacted with 2.000 moles of water

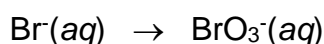
and 98.048 grams of hydrogen bromide were obtained, what was the percent yield from the reaction? (2)

- 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.

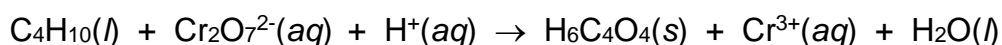
7. Complete the balancing of the following half-reaction, taking place in basic media,



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,



The oxidizing agent is (1)

- a. $\text{C}_4\text{H}_{10}(l)$
- b. $\text{Cr}_2\text{O}_7^{2-}(aq)$
- c. $\text{H}^+(aq)$
- d. $\text{H}_6\text{C}_4\text{O}_4(s)$
- e. $\text{Cr}^{3+}(aq)$

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)

$n \quad l \quad m_l \quad m_s$

- | | |
|-------------------------------|--------------------------------|
| a. 4 2 2 $-\frac{1}{2}$ | b. 3 1 -1 -1 |
| c. 4 3 2 $\frac{1}{2}$ | d. 4 3 -2 $-\frac{1}{2}$ |
| e. 5 2 2 $\frac{1}{2}$ | |

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)

- the OH^- ion acts as a Lewis base, donating an electron pair to the SO_2 molecule to form a coordinate covalent bond.
- the SO_2 acts as a Lewis acid, accepting a proton from the OH^- ion.
- the OH^- ion acts as a Brønsted base, donating a proton to the SO_2 molecule.
- 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) disulphur 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 $\text{Na}_2\text{Cr}_2\text{O}_7$ 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.

- Write a balanced net ionic equation for the reaction between Sn^{2+} and $\text{Cr}_2\text{O}_7^{2-}$ in an acidic solution. (3)
- Calculate the number of grams of tin that were in the sample of solder. (2)
- What was the percentage by mass of tin in the solder? (2)
- How many Pb atoms are present in the Solder alloy sample? (2)

Question 2

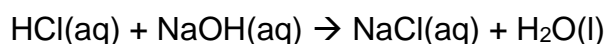
[20 MARKS]

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 your reasoning. (3)

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

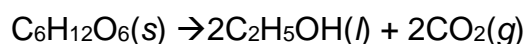
2.2) How many milligrams of MgI_2 must be added to 250.0 mL of 0.0876 M KI to produce a solution with $[\text{I}^-] = 0.1000 \text{ M}$? (4)

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:



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:



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 $\text{Mg}(\text{OH})_2$ is basic, but $\text{Si}(\text{OH})_4$ 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:

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

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$h = 6.626 \times 10^{-34} \text{ J.s (Planck's constant)}$$

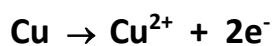
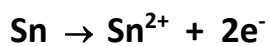
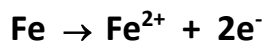
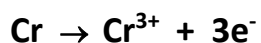
$$R_H = 1.097 \times 10^7 \text{ m}^{-1}$$

$$c = 3.00 \times 10^8 \text{ m.s}^{-1}$$

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

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

Activity of metals:



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

$$PV = nRT$$

$$R = 0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$$

$$760 \text{ mmHg} = 760 \text{ torr} = 1 \text{ atm}$$