



LAST NAME: \_\_\_\_\_  
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SIGNATURE: \_\_\_\_\_  
STUDENT ID#: \_\_\_\_\_

Course: CHEMISTRY

Number: 205/2

Section: 01, 02 and 51

Instructors: G. Dénès, G. Kos, C.W. Rogers

Examination: Final

Date: 6<sup>th</sup> December, 2008

Time: 09:00 - 12:00

# of pages: 7

**Materials Allowed:** A data sheet and periodic table are attached to this paper - *no other materials are allowed*. You may tear off the data sheet and periodic table if you wish.

**Calculators Allowed:** Yes (But NO OTHER ELECTRONICS are allowed, except a wrist-watch.)

**Special Instructions:**

**PLEASE READ THIS PAGE WHILE YOU WAIT TO START.**

- Check that your exam has 7 pages (p.1-14, double-sided). Write your ID # on all pages.
- Read all questions carefully **BEFORE** starting the exam, and answer **ALL** questions.
- This exam contains three sections. Please read the instructions for each section carefully.
  - Write answers to Section I (multiple choice) on the computer-gradable form provided.
  - Write answers to Sections II & III on the exam paper (use backs of pages for rough work).
  - Show your work for all calculation questions, or you will NOT get full marks.
- **PLEASE RAISE YOUR HAND IF YOU NEED CLARIFICATION.**

Please leave this area blank

**Section I.**

The following 20 questions are multiple choice, worth 2 marks each. There is only ONE correct choice for each question. You may do rough work on your exam paper, but it will not be marked. You must mark your answers using a soft pencil on the computer-gradable answer form provided. Do not forget to mark your name and student number (your birth date is not required).

- An electronic balance is used to determine the mass of a sample of NaCl crystals. If 25.717 g of NaCl is weighed on an instrument with a precision of  $\pm 1$  mg, what is the correct number of *significant figures* for this measurement?
  - 1
  - 2
  - 3
  - 4
  - 5
- Which of the following statements is *not true* about the periodic table? (QUESTION NOW FIXED)
  - It collects elements together as non-metals (groups 1-6), metals (7-12) and metalloids (13-18).
  - It helps us remember trends in atom sizes, electronegativities and valence electrons.
  - It is a representation of the periodicity of properties of the elements.
  - It lists elements with increasing atomic number.
  - It lists similarly behaving elements in groups.
- Which of the following elements will have the *largest mass*, if you provide exactly 1 mole of this element?
  - Phosphorus
  - Bromine
  - Calcium
  - Copper
  - Silicon
- Which of the following statements is a basic definition of *chemical change*?
  - Chemical change involves a change in the total number of atoms in the sample.
  - Chemical change involves a change in the interactions between the molecules.
  - Chemical change involves a change in the organization of the molecules.
  - Chemical change involves a change in the identity of the substance(s).
  - Chemical change involves a change of state.
- What is the *stoichiometric coefficient* for oxygen when the following equation is balanced (using whole-number coefficients)?  
(Unbalanced)  $\text{NH}_3(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$ 
  - 3
  - 6
  - 7
  - 12
  - 14

6. Which of the following statements is *true* for barium chloride, BaCl<sub>2</sub>?
- BaCl<sub>2</sub> is a heterogeneous mixture of Ba(s) and Cl<sub>2</sub>(s).
  - BaCl<sub>2</sub> is a homogeneous mixture of Ba(s) and Cl<sub>2</sub>(s).
  - BaCl<sub>2</sub> is a molecular compound.
  - BaCl<sub>2</sub> is an ionic compound.
  - All of the above are false.
7. Which of the statements below summarizes *J.J. Thomson's hypothesis* on atomic structure?
- Chemical reactions involve the reorganization of atoms but the atoms themselves are unchanged.
  - Electrons occupy 3-dimensional orbitals around the nucleus, which vary in energy and shape.
  - A dense, positively charged nucleus is surrounded by negatively charged electrons.
  - Atoms are not indivisible, because some can disintegrate and emit radiation.
  - Electrons are distributed evenly in a spherical cloud of positive charges.
8. Which one of the following statements correctly describes a reaction's *spectator ions*?
- They are ions that precipitate out of the solution as a solid during the reaction.
  - They are freely dissociated ions that are not consumed during the reaction.
  - They are excess reactants that are not consumed during the reaction.
  - They limit the amount of product that is formed during the reaction.
  - They are included in the reaction's net ionic equation.
9. Aqueous solutions of sodium sulfide and copper(II) chloride are mixed together. Which statement correctly summarizes *what happens*?
- Both NaCl and CuS precipitate from solution.
  - NaCl precipitates from solution.
  - CuS precipitates from solution.
  - No precipitate forms.
  - No reaction occurs.
10. All three of the reactions shown below can be *classified* as:
- $$2 \text{Al(s)} + 3 \text{Br}_2\text{(l)} \rightarrow 2 \text{AlBr}_3\text{(s)}$$
- $$2 \text{Ag}_2\text{O(s)} \rightarrow 4 \text{Ag(s)} + \text{O}_2\text{(g)}$$
- $$\text{CH}_4\text{(l)} + 2 \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)} + 2 \text{H}_2\text{O(g)}$$
- oxidation-reduction reactions.
  - precipitation reactions.
  - gas-forming reactions.
  - combustion reactions.
  - acid-base reactions.
11. What *mass* of calcium chloride, CaCl<sub>2</sub>, is needed to prepare 2.850 L of a 1.56 M solution?
- 25.9 g
  - 60.8 g
  - 111 g
  - 203 g
  - 493 g

12. Using Bohr's model of the hydrogen atom, give the *starting orbit number* for an electron moving to the nearest orbit (higher or lower) that results in the emission of the radiation having the *shortest* possible wavelength.
- 1
  - 2
  - 3
  - 4
  - $\infty$
13. Which of the following statements is *incorrect* regarding electromagnetic radiation?
- The energy of ultraviolet radiation is larger than that of infrared radiation.
  - The wavelength of radiowaves is shorter than that of infrared radiation.
  - The wavelength of radiowaves is larger than that of visible light.
  - The frequency of red light is lower than that of blue light.
  - The energy of gamma-rays is larger than that of X-rays.
14. Which of the following values below is equal to the number of nodal surfaces an orbital has that slice through the nucleus of the atom?
- Angular momentum quantum number,  $l$
  - Electron spin quantum number,  $m_s$
  - Magnetic quantum number,  $m_l$
  - Principal quantum number,  $n$
  - $(2l + 1)$
15. Which of the following is the observed *valence electron configuration* for copper, Cu?
- $[\text{Ar}] 3d^9 4s^1 4p^1$
  - $[\text{Ar}] 3d^{10} 4s^2$
  - $[\text{Ar}] 3d^{10} 4p^2$
  - $[\text{Ar}] 3d^{10} 4s^1$
  - $[\text{Ar}] 3d^9 4s^2$
16. Use the orbital box notation for the following elements and determine which ones, present as single atoms, would give rise to *paramagnetism*: N, Zn, Ar, Co, Ca
- only Zn, Co and Ca
  - only Zn, Ar and Ca
  - only N and Co
  - only N and Ar
  - all of them
17. Which of the following atoms has the highest *electron affinity*?
- Li
  - Be
  - B
  - C
  - N

18. Which ONE of the following statements is true about *bond strength*?
- The same types of atoms bonded via the same bond order will have similar bond strengths.
  - Any types of atoms bonded via the same bond order will have similar bond strengths.
  - Bond strength is the energy required to break an ionic compound into neutral atoms.
  - Bond strength is the energy required to break an ionic compound into its ions.
  - Shorter bonds are always stronger than longer bonds.
19. Which of the following laws / hypotheses showed that there must be a minimum possible temperature (which gave rise to the *absolute temperature* scale)?
- Dalton's law of partial pressures
  - Avogadro's hypothesis
  - Charles's law
  - Ideal gas law
  - Boyle's law
20. Which of the following conditions would make a gas have close to *ideal behaviour*?
- Large, highly polar molecules at low temperature
  - High pressure and high temperature
  - Low pressure and high temperature
  - High pressure and low temperature
  - Low pressure and low temperature

You may use the rest of this page for rough work.

**Section II.**

The following 6 questions (#21-26) require short answers and should be answered in the space provided on this paper.

21. (3 marks) Provide the missing name or formula for each substance below:

NaNO<sub>2</sub> \_\_\_\_\_

SO<sub>2</sub> \_\_\_\_\_

TiCl<sub>2</sub> \_\_\_\_\_

\_\_\_\_\_

dinitrogen tetraoxide

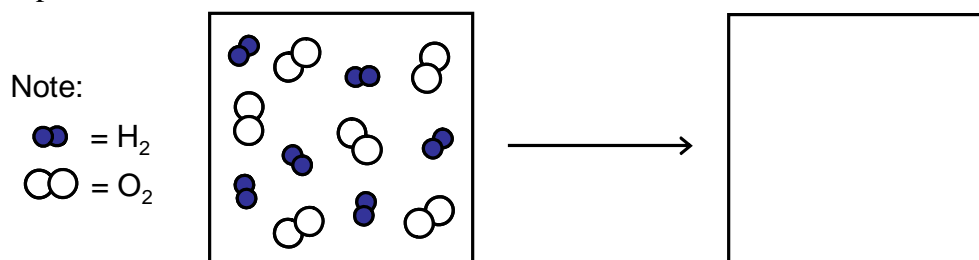
\_\_\_\_\_

potassium chlorate

\_\_\_\_\_

calcium nitrate

22. (6 marks) A few hydrogen and oxygen molecules are introduced into a container in the quantities depicted in the diagram below. These gases are then ignited by a spark, causing them to react to form water vapour.



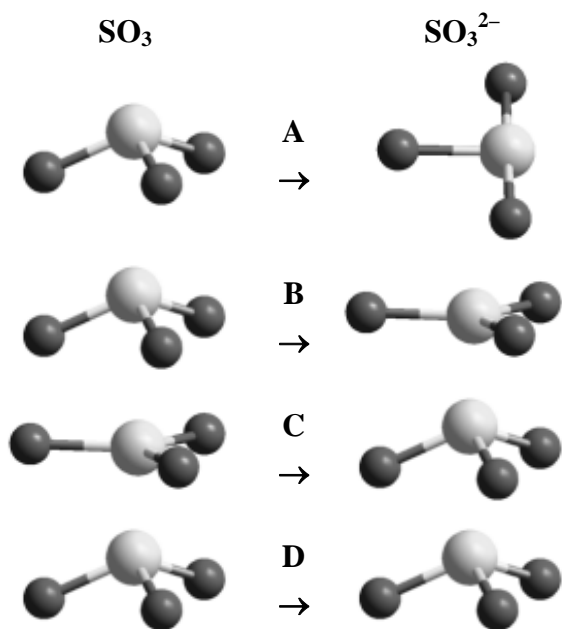
- a) (1 mark) Write a balanced chemical equation for the reaction.
- b) (3 marks) Determine the maximum number of water molecules that can be formed from our sample of hydrogen and oxygen. Explain briefly.
- c) (2 marks) In the empty box above, draw a molecular level representation (like the diagram given) of the container's contents after the reaction.

23. (4 marks) Use the position of chlorine in the periodic table to explain whether it is a strong reducing agent or a strong oxidizing agent. Provide one example of a balanced equation that illustrates this behaviour.

24. (5 marks) When  $\text{SO}_3$  gains two electrons,  $\text{SO}_3^{2-}$  forms.

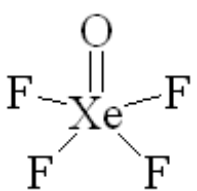
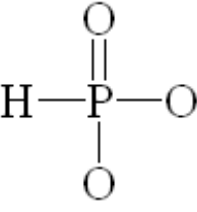
a) (4 marks) Which picture (A-D) below best illustrates the change in molecular geometry around S?

Explain your choice.

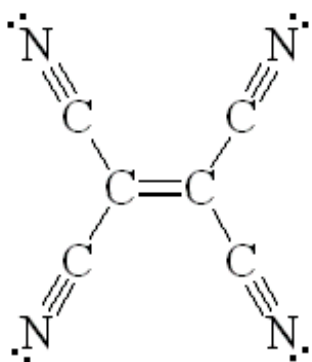


b) (1 mark) Does the molecular polarity change during this reaction? Explain briefly.

25. (8 marks) For each of the diagrams below, mark in all the missing lone-pairs and formal charges where appropriate. *Do not change the number of bonds, and respect the charges on the species shown to their left.* Supply the information requested in the right-hand column.

Charge	Lewis Structure	
zero		(a) Electron pair (basic) geometry (b) Molecular (observed) geometry (c) Xenon hybridization
-2		(a) Total number of equivalent structures <i>including</i> this one. (b) Average phosphorus oxygen bond order (c) Average charge on oxygen

26. (4 marks) The molecule tetracyanoethylene has been used in attempts to synthesize organic superconducting materials. Its structure is shown below.



- How many sigma ( $\sigma$ ) bonds does it contain (in total)?
- How many pi ( $\pi$ ) bonds does it contain (in total)?
- Is this molecule polar, or non-polar?
- Sketch how two p-orbitals overlap to form a  $\pi$ - bond.



**Section III.**

**Answer the following 2 problems (#27-28) on the exam paper, with *complete* written answers including calculations. Be sure to provide adequate explanations or details to justify your answers. Use the backs of the pages if you need more space.**

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27. (10 marks) Caffeine, a stimulant found in coffee, tea, and energy drinks, contains C, H, O, and N. Combustion of 1.000 mg of caffeine produces 1.813 mg CO<sub>2</sub>, 0.4639 mg H<sub>2</sub>O, and 0.2885 mg N<sub>2</sub>. Calculate the molecular formula of caffeine, whose molar mass lies between 150 and 200 g/mol.

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Use this page for rough work, or if you run out of space.

28. (10 marks) Lakes that have been acidified by acid rain ( $\text{HNO}_3$  and  $\text{H}_2\text{SO}_4$ ) can be neutralized by a process called *liming*, in which limestone ( $\text{CaCO}_3$ ) is added to the lake. The reactions involved are:



a) (2 marks) What type of reaction are these (circle all that apply)?

*precipitation, acid-base, oxidation-reduction, gas-forming*

b) (8 marks) What mass of limestone (in kg) would be required to completely neutralize a 15.2-billion litre lake ( $15.2 \times 10^9$  L) that is  $1.8 \times 10^{-5}$  M in  $\text{H}_2\text{SO}_4$  and  $8.7 \times 10^{-6}$  M in  $\text{HNO}_3$ ?

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Use this page for rough work, or if you run out of space.

**POTENTIALLY USEFUL INFORMATION**

Atomic mass unit	$1 \text{ amu} = 1.66054 \times 10^{-27} \text{ kg}$
Avogadro's number	$N = 6.022 \times 10^{23} \text{ mol}^{-1}$
Definition of <i>Joule</i>	$1 \text{ J} = 1 \text{ kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$
Definition of <i>Pascal</i>	$1 \text{ Pa} = 1 \text{ kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$
Gas constant	$R = 0.08206 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \text{K}^{-1} = 8.314 \text{ J} \cdot \text{mol}^{-1} \text{K}^{-1}$
Planck's constant	$h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$
Pressure units	$760 \text{ mm Hg} = 760 \text{ torr} = 1 \text{ atm} = 101.325 \text{ kPa} = 1.01325 \text{ bar}$
Rydberg constant	$R = 1.0974 \times 10^7 \text{ m}^{-1}$
Speed of light	$c = 2.9979 \times 10^8 \text{ m} \cdot \text{s}^{-1}$

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