



# Examination Cover Sheet

<b>COURSE:</b> Chem	<b>NUMBER:</b> 205	<b>SECTION(S):</b> 03, 04, 53	
<b>EXAMINATION:</b> <input checked="" type="checkbox"/> <b>FINAL</b> <input type="checkbox"/> <b>ALTERNATE</b> <input type="checkbox"/> <b>DEFERRED</b> <b>VERSION:</b> _____	<b>DATE:</b> April 22, 2015	<b>TIME:</b> 7-10 pm	<b>PAGES:</b> 14 Including cover
<b>INSTRUCTOR(S):</b> P. Bird		<b>DIVISION:</b>	
<b>MATERIALS ALLOWED:</b> <input type="checkbox"/> <b>No!</b> Booklets <input checked="" type="checkbox"/> IBM (Scantron) <input checked="" type="checkbox"/> Blue <b>or</b> <input type="checkbox"/> Green <input checked="" type="checkbox"/> Printed Translation Dictionary Other <b>NO</b> _____ <input checked="" type="checkbox"/> Calculator <input type="checkbox"/> ENCS Approved <input type="checkbox"/> Other <b>No</b> _____		<b>INSTRUCTIONS:</b> <input checked="" type="checkbox"/> Return all <input checked="" type="checkbox"/> Answer on Exam <input type="checkbox"/> Open book <input type="checkbox"/> Crib sheet Details _____	

**Please print your name, I.D. number and section in the appropriate spaces below.**

**STUDENT LAST NAME:** \_\_\_\_\_

**STUDENT FIRST NAME:** \_\_\_\_\_

**I.D. NO.** \_\_\_\_\_ **SECTION:** \_\_\_\_\_

**SPECIAL INSTRUCTIONS:**

Use pages 11, 12 and 13 of this paper for rough work. This will NOT be graded.

If you need extra space for an answer, use this space too, but indicate this **very** clearly.

Potentially useful information, and a periodic table are on pages 13 and 14. No other periodic table is allowed.

Please do not write in this table.

Section I	Section II	Section III	Total

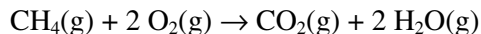
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**Section I. The following 30 questions are multiple choice. They are worth 2 marks each. You may do rough work on the exam paper, but it will not be marked. You *must* mark your answers using a soft pencil on the machine readable answer form provided. Do not forget to mark your name and student number. (Your birth date is not required.)**

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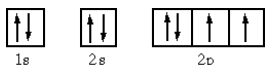
- All atoms of the same element have the same number of \_\_\_\_\_ in their nucleus. What is the missing word or words?
  - neutrons
  - electrons
  - protons
  - neutrons and protons
  - neutrons, protons, and electrons
- What method is used to determine the exact masses of isotopes and their relative abundances?
  - Elemental analysis
  - Millikan's oil drop experiment
  - Spectrophotometry
  - Rutherford's  $\alpha$ -scattering experiment
  - Mass spectrometry
- Which pair of atoms have the same number of neutrons?
  - ${}_{12}^{28}\text{Mg}$  and  ${}_{11}^{28}\text{Na}$
  - ${}_{12}^{26}\text{Mg}$  and  ${}_{12}^{28}\text{Mg}$
  - ${}_{14}^{28}\text{Si}$  and  ${}_{12}^{28}\text{Mg}$
  - ${}_{14}^{28}\text{Si}$  and  ${}_{11}^{28}\text{Na}$
  - ${}_{14}^{28}\text{Si}$  and  ${}_{12}^{26}\text{Mg}$
- What are the values for x and y for  $\text{Al}_x(\text{CO}_3)_y$ ?
  - x = 1 and y = 2
  - x = 2 and y = 3
  - x = 1 and y = 3
  - x = 3 and y = 1
  - x = 3 and y = 2
- The density of carbon tetrachloride is 1.59 g/mL. How many moles are present in 50.0 mL of carbon tetrachloride?
  - 0.204 g/mol
  - 0.517 mol
  - 0.0103 mol
  - 1.02 mol
  - 0.325 mol

6. Methane reacts with oxygen to form carbon dioxide and water.



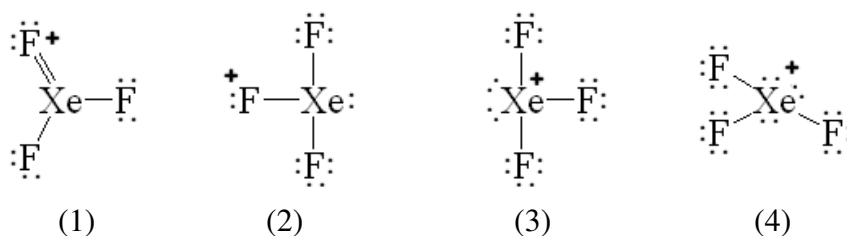
All of the following statements concerning this reaction are correct EXCEPT:

- two moles of water are formed for one mole of methane consumed.
  - two molecules of oxygen are consumed per one molecule of methane consumed.
  - the combined mass of reactants consumed equals the mass of products formed.
  - two grams of oxygen are consumed for each gram of carbon dioxide formed.
  - three moles of gases are formed for each three moles of gases consumed.
7. What is the formula of chromium (III) oxide?
- $\text{Cr}_2\text{O}_3$
  - $\text{Cr}_3\text{O}_2$
  - $\text{CrO}_3$
  - $\text{Cr}_3\text{O}$
  - $\text{Cr}_3\text{O}_3$
8. What is the net ionic equation for the reaction of potassium hydroxide and hydrochloric acid in aqueous solution?
- $\text{H}^+(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell) + \text{K}^+(\text{aq})$
  - $\text{K}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{KCl}(\text{aq})$
  - $\text{HCl}(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell)$
  - $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell)$
  - $\text{KOH}(\text{aq}) + \text{H}_2\text{O}(\ell) \rightarrow \text{H}^+(\text{aq}) + \text{K}(\text{OH})_2(\text{s})$
9. Which of the following compounds you would expect to be *the most* soluble in water?
- $\text{AgCl}$
  - $\text{PbSO}_4$
  - $\text{KNO}_3$
  - $\text{Fe}(\text{OH})_3$
  - $\text{Ca}_3\text{PO}_4$
10. What is the oxidation number of chromium in  $\text{K}_2\text{Cr}_2\text{O}_7$
- 7
  - 6
  - +2
  - +6
  - +7
11. Which of the following directions correctly describe the preparation of 0.500 L of 0.150 M NaOH from a 6.00 M stock solution?
- Dilute 0.200 L of 6.00 M NaOH to a volume of 0.500 L.
  - Dilute 12.5 mL of 6.00 M NaOH to a volume of 0.500 L.
  - Combine 0.200 L of 6.00 M NaOH with 0.500 L of water.
  - Dilute 475 mL of 6.00 M NaOH to a volume of 0.500 L.
  - Combine 12.5 mL of 6.00 M NaOH with 0.500 L of water.

12. What is the energy of a single photon of  $\gamma$ -radiation with a wavelength of  $1.33 \times 10^{-12}$  m?
- $9.34 \times 10^{-18}$  J
  - $4.41 \times 10^{-15}$  J
  - $1.49 \times 10^{-13}$  J
  - $8.34 \times 10^{-12}$  J
  - $2.10 \times 10^{-11}$  J
13. What type of orbital is designated by  $n = 2, \ell = 0, m_\ell = 0$ ?
- 2s
  - 2p
  - 2d
  - 2f
  - None
14. Which of the following is associated with the value of the  $m_\ell$  quantum number?
- orbital orientation
  - number of nodes
  - angular momentum quantum number
  - orbital size
  - de Broglie wavelength
15. How many electrons can be described by the quantum numbers  $n = 4, \ell = 2, m_s = +1/2$ ?
- 1
  - 2
  - 3
  - 5
  - 10
16. What element has the following electron configuration?
- 
- 1s      2s      2p
- P
  - S
  - O
  - N
  - F
17. Which of the following chemical equations refers to the second ionization of Ca?
- $\text{Ca(s)} + 2\text{e}^- \rightarrow \text{Ca}^{2-}(\text{s})$
  - $\text{Ca(g)} \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^-$
  - $\text{Ca}^{2+}(\text{g}) \rightarrow \text{Ca}^+(\text{g}) + \text{e}^-$
  - $\text{Ca(s)} \rightarrow \text{Ca}^+(\text{s}) + \text{e}^-$
  - $\text{Ca}^+(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^-$

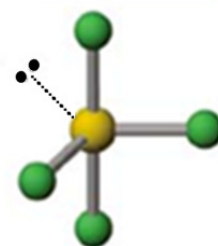
18. Which type of elements have *least* affinity for electrons?
- transition metals
  - main group metals
  - noble gases
  - main group nonmetals
  - semiconductors
19. Which of the following elements is most likely to form a molecule that does not obey the octet rule?
- B
  - C
  - N
  - O
  - F

20. What is the correct Lewis structure for  $\text{XeF}_3^+$  with the correctly placed formal charge?



- 1
  - 2
  - 3
  - 4
  - 1 or 2
21. A ball-and-stick structure of  $\text{AsF}_4^-$  is shown on the right. How is the *electron-pair* (basic) geometry described?

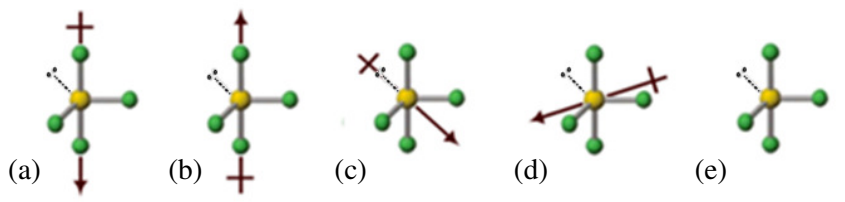
- pentagonal
- seesaw
- trigonal bipyramidal
- tetrahedral
- square planar



22. How is the *molecular* geometry of  $\text{AsF}_4^-$  (see figure in Q21) described?
- pentagonal
  - see-saw
  - trigonal bipyramidal
  - tetrahedral
  - Square planar

23. In  $\text{AsF}_4^-$  (see figure in Q21), the lone-pair is observed to be in an equatorial site, and not axial. Why is this geometry favoured?
- Arsenic atoms are bigger than fluorine.
  - Arsenic is less electronegative than fluorine.
  - No reason. That is just the way it is.
  - The bulky lone-pair makes fewest  $90^\circ$  angles with As-F bond-pairs.
  - It is warmer near the equator.

24.  $\text{SF}_4$  is isoelectronic and isostructural with  $\text{AsF}_4^-$ . How is it polarized (see figures or text below)?



- It is polarized with the net dipole along the axial direction, positive at the top.
  - It is polarized with the net dipole along the axial direction, positive at the bottom.
  - It is polarized with the net dipole aligned with the S – lone-pair axis.
  - It is polarized with the net dipole perpendicular to the S – lone-pair axis and the axial direction.
  - It is not polarized.
25. Predict which of the following compounds will have the X-H bond that is most polar.
- $\text{NH}_3$
  - $\text{CF}_4$
  - $\text{H}_2\text{O}$
  - $\text{HF}$
  - $\text{HI}$

26. Use VSEPR theory to predict the molecular geometry of  $\text{IF}_5$ .

- tetrahedral
- trigonal bipyramidal
- see-saw
- square pyramidal
- octahedral

27. What is the hybridization of the central nitrogen in  $\text{N}_3^-$ ?

- $sp$
- $sp^2$
- $sp^3$
- $sp^3d$
- $sp^3d^2$

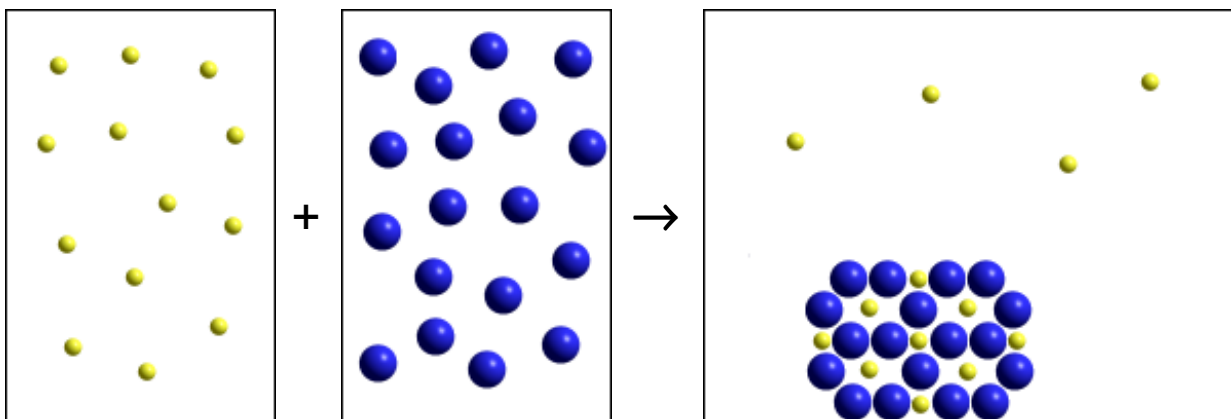
28. One product of the combustion of methane is carbon dioxide. What change in the hybridization of the carbon occurs in this reaction?

- $sp^3$  to  $sp^2$
- $sp^3$  to  $sp$
- $sp^3$  to  $sp^3d$
- $sp^2$  to  $sp^3d^2$
- $sp^2$  to  $sp$

29. What is the density of carbon dioxide at standard temperature and pressure (STP)?
- 0.89 g/L
  - 1.00 g/L
  - 1.32 g/L
  - 1.68 g/L
  - 1.96 g/L
30. If 2.50 g of ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) is burned in excess oxygen in a 10.0 L container, what is the resulting partial pressure (in atmospheres, atm) of the carbon dioxide produced at 25 °C?
- 0.0223 atm
  - 0.266 atm
  - 2.26 atm
  - 26.9 atm
  - $2.69 \times 10^2$  atm

**Section II. The following questions require short answers on this exam paper in the space provided. Be sure to give explanations where required.**

31. Assume that an aqueous solution containing a cation (smaller light spheres) is allowed to mix with a solution containing an anion (larger dark spheres), and that the diagram on the right illustrates the result which is obtained. (The solvent water molecules and spectator counter-ions are not shown.)

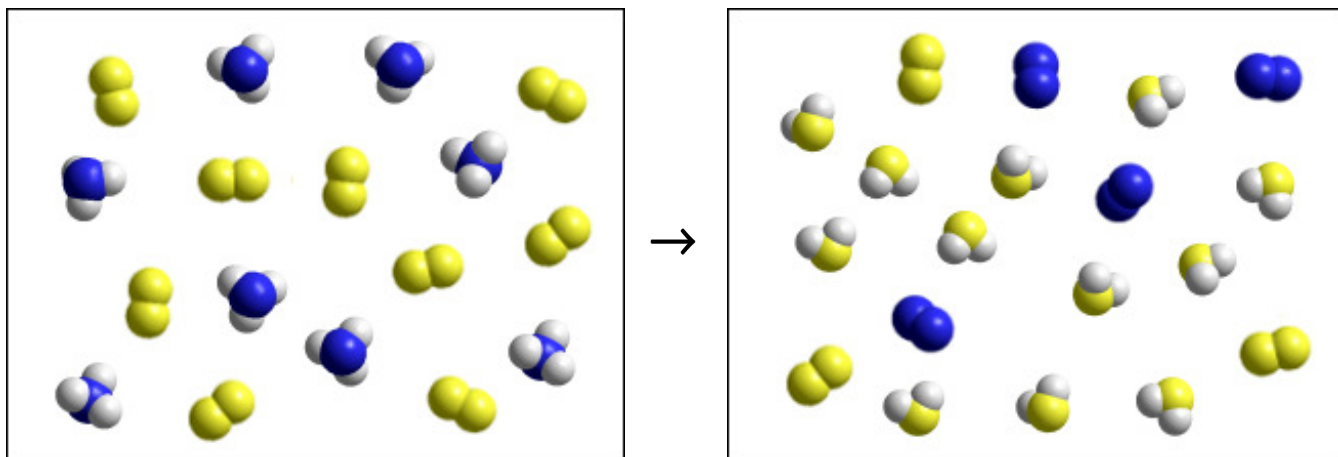


(2 marks) Which combination of cation and anion, chosen from the following lists, are compatible with the observed results? Explain briefly how you made your decision.

Cations:  $\text{K}^+$ ,  $\text{Ni}^{2+}$ ,  $\text{NH}_4^+$ ,  $\text{Ba}^{2+}$

Anions:  $\text{OH}^-$ ,  $\text{NO}_3^-$ ,  $\text{ClO}_4^-$ ,  $\text{SO}_4^{2-}$

32. The two pictures below show the *gas-phase* reaction between reactants  $AH_3$  and  $X_2$  to form products  $A_2$  and  $XH_2$ , where A are the dark coloured atoms and X are the (larger) light coloured atoms. (The smaller light coloured atoms are hydrogen, H.)



- (a) The elements A and X are actually real elements to be found between Li and Ne in the periodic table. Identify the reactants and products, briefly explaining your reasoning (1 mark). Say which reactant is limiting (1 mark), and write a balanced equation for the reaction (1 mark).
- (b) (1 mark) In a real reaction, *with the same proportions* of reactants, the pressure of the reactant mixture was 1.00 atm. If the temperature and container volume are not changed, what (according to Avogadro's hypothesis) is the pressure after the reaction?

33. (1 mark each) Complete each of the following five statements appropriately.
- (a) The lowest energy state of an atom is called its \_\_\_\_\_ state.
  - (b) A \_\_\_\_\_ is a particle of radiation of zero mass.
  - (c) Half the distance between two metal atoms in a crystal of the pure metal is called the \_\_\_\_\_ of the metal.
  - (d) In addition to being farthest from the nucleus, the electrons in the \_\_\_\_\_ shell are also responsible for an element's chemical properties.
  - (e) In valence bond theory, a  $\pi$  bond *between elements of the second period* is made from the side-by-side overlap of two unhybridized orbitals of type \_\_\_\_\_.

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**Section III. Answer the following 2 questions with complete written answers on the this exam paper. There is a blank page at the end if you need more space. Be sure to provide adequate explanations or details to justify you answers where it is appropriate. No explanation - half-marks max!**

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34. Sulphuric acid is listed in a catalog as having a concentration of 95-98% by weight. The label on a bottle in the stockroom shows the density as 1.85 g/mL. In order to (safely) determine the actual concentration of acid in the bottle, a student dilutes 5.00 mL of the concentrated acid to 500. mL. She then takes four 10.00 mL samples and titrates each with standardized 0.1790 M sodium hydroxide solution. The results (in order) were:

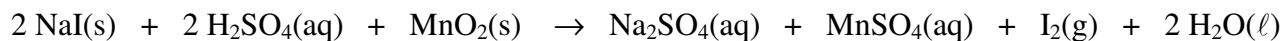
Sample	1st	2nd	3rd	4th
Volume NaOH (mL)	~20.70	20.30	20.40	20.35

- (a) (3 marks) What is the molarity of the *concentrated* sulphuric acid in the bottle?

Part (b) is on page 10.

- (b) (1 marks) What is the true mass percent of concentrated acid in the stock bottle?

35. The following reaction can be used to prepare iodine in the laboratory:



- (a) (1 mark) What is the oxidizing agent, and what has been oxidized?

Oxidizing Agent: \_\_\_\_\_ Oxidized: \_\_\_\_\_

- (b) (1 mark) What is the reducing agent, and what has been reduced?

Reducing agent: \_\_\_\_\_ Reduced: \_\_\_\_\_

- (c) (3 marks) What mass of iodine can be obtained if 20.0 g of NaI is mixed with 10.0 g of  $\text{MnO}_2$  and treated with an excess of sulphuric acid?

- (d) (1 mark) If, after the actual reaction, 14.3 g of solid  $\text{I}_2$  were isolated, what was the percentage yield?

Use this page if you need extra space, or to do rough work.

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### 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	$c = 2.9979 \times 10^8 \text{ m} \cdot \text{s}^{-1}$



