Course: CHEMISTRY	**Number:** 205/4	**Section:** 03 and 04	
Instructors: P.H. Bird, C.W. Rogers			
Examination: Final	**Date:** 14th April, 2008	**Time:** 14:00 - 17:00	**# of pages:** 15
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 cell phones or electronic dictionaries may NOT be used as calculators.)			
Special Instructions: This exam contains three sections. ***Please read the instructions before each section carefully.***			

LAST NAME: _____ FIRST NAME: _____

STUDENT NUMBER: _____ SIGNATURE: _____

PLEASE READ THIS PAGE WHILE YOU WAIT TO START.

- ***Check that you have 15 pages including this page. Please write your ID # on all pages.***
- ***A periodic table and "useful information" are provided; you CAN remove those pages.***
- ***Non-programmable calculators are allowed; cell phones & electronic dictionaries are not.***
- ***Read ALL questions carefully BEFORE starting the exam, and answer ALL questions.***
- ***Write all answers in the space provided (use the backs of the pages for rough work).***
- ***SHOW YOUR WORK FOR ALL CALCULATIONS, or you will NOT get full marks.***

GOOD LUCK! PLEASE RAISE YOUR HAND IF YOU NEED CLARIFICATION.

Please leave this area blank

Section I. The following 20 questions are multiple choice. They are worth 2 marks each. 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 machine readable answer form provided. *Do not forget to mark your name and student number (your birth date is not required).*

1. All of the following processes are chemical properties of sodium, ***except:***

   i. It's freshly cut shiny surface turns black on exposure to air.

   ii. It is a solid at 25 ^{o}C, but changes to a liquid at 98 ^{o}C.

   iii. When a small piece is placed in water, it sizzles, and a gas is formed.

   iv. When exposed to chlorine gas it forms a compound which melts at 801 ^{o}C.

   v. Its vapour (for example, in streetlights) emits yellow light when an electric current is passed through it.

   a. (iii) and (iv)
   b. (i) and (v)
   c. (ii) and (v)
   d. (ii), (iv) and (v)
   e. (iii), (iv) and (v)

2. A student gradually heats some tap water in a beaker in the lab. When the water reaches 30 ^{o}C bubbles slowly begin to form on the walls of the beaker and eventually float to the surface. At 100 ^{o}C bubbles are forming rapidly throughout the water as it boils. Which of the following statements describes the composition of the bubbles at the lower temperature, and at the boiling point?

	At 30 ^{o}C	**At 100 ^{o}C**
a.	H_2O (g)	H_2 (g) + O_2 (g)
b.	H_2O (g)	OH^- (g) + H^+ (g)
c.	Mostly O_2 (g) and N_2 (g) and some H_2O (g)	H_2O (g)
d.	H_2O (g)	Mostly O_2 (g) and N_2 (g), and some H_2O (g)
e.	CO (g) + O_2 (g)	CO_2 (g)

3. An ion of aluminum-26, Al^{3+} has:

   a. 13 protons, 13 neutrons, and 13 electrons
   b. 13 protons, 10 neutrons, and 26 electrons
   c. 13 protons, 13 neutrons, and 16 electrons
   d. 10 protons, 13 neutrons, and 13 electrons
   e. 13 protons, 13 neutrons, and 10 electrons

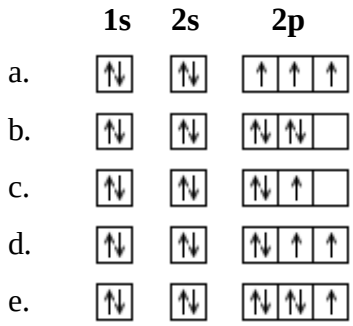
4. Which pair of elements would be most likely to form an ionic compound with each other?
   a. Phosphorus and Bromine
   b. Zinc and Potassium
   c. Fluorine and aluminum
   d. Carbon and sulphur
   e. Titanium and zinc

5. Which of the following statements does ***not*** correctly describe the reaction between sodium carbonate and hydrochloric acid?
   a. The reaction can be classified as an acid-base reaction.
   b. The reaction would not be visibly obvious.
   c. The sodium ions would be described as spectator ions.
   d. The reaction involves the evolution of gas.
   e. None – all of the above statements are true.

6. Complete the following sentence: Atoms emit electromagnetic radiation including visible light:
   a. when electrons in atoms jump from lower to higher energy levels.
   b. when atoms condense from a gas to a liquid
   c. when electrons in atoms move across nodes in atomic orbitals
   d. when electrons in atoms fall from higher to lower energy levels.
   e. when electrons fall into the nucleus and are captured by protons.

7. In an electron microscope, electrons are accelerated to high velocities and have associated wavelengths suitable for "viewing" very small objects. What is the wavelength associated with an electron moving at 7.0×10^{6} m s^{-1}? (The mass of the electron is 9.11×10^{-28} g)
   a. 1.0×10^{-13} m
   b. 1.0×10^{-7} m
   c. 1.0 m
   d. 1.0×10^{-10} m
   e. 1.0×10^{13} m

8. Which diagram correctly represents the ground state electronic configuration of oxygen?



9. Consider each of the configurations shown in question 8. Which are ***not*** ground states according to Hund's rule?
   a. Configurations a, c, d and e.
   b. Configuration b only.
   c. Configurations a, d and e.
   d. Configuration a only.
   e. Configurations b and c.

10. By what name are the elements of group 17 of the periodic table known?
   a. The chalcogens
   b. The acid gases
   c. The actinides
   d. The halogens
   e. The fluorinoids

11. An element has the following sequence of ionization energies:

   $X \rightarrow X^{+}$ I.E. = 737 kJ mol^{-1}

   $X^{+} \rightarrow X^{2+}$ I.E. = 1450 kJ mol^{-1}

   $X^{2+} \rightarrow X^{3+}$ I.E. = 7732 kJ mol^{-1}

   Which of the following elements is it?
   a. Hydrogen
   b. Sodium
   c. Magnesium
   d. Aluminum
   e. Argon

12. What kind of oxides would be compounds such as NO_2, P_2O_5, SO_2 etc. be?
    a. Acidic oxides
    b. Ionic oxides
    c. Neutral oxides
    d. Basic oxides
    e. Bionic oxides

13. What is the H^+ concentration in hydrochloric acid with a pH of 2.30?
    a. 2.30 M
    b. 0.0050 M
    c. 1.99×10^2 M
    d. –2.30 M
    e. 0.0030 M

14. Crystals of ionic compounds are held together by electrostatic forces. Which of the following statements characterize the potential energy associated with these forces?
    a. Directly proportional to the product of the charges on the ions, and inversely proportional to the distance between them.
    b. Directly proportional to the product of the charges on the ions, and directly proportional to the distance between them.
    c. Inversely proportional to the product of the charges on the ions, and directly proportional to the distance between them.
    d. Inversely proportional to the product of the charges on the ions, and directly proportional to the distance between them.
    e. Directly proportional to the sum of the charges on the ions and directly proportional to the distance between them.

15. In the compounds indicated, which pair of elements would participate in the most polar covalent bond?
    a. The two nitrogen atoms in H–N=N–H (g)
    b. The two oxygen atoms in H–O–O–H (l)
    c. The fluorine atoms in F–F (g)
    d. Cesium and chlorine in CsCl (s)
    e. Silicon and carbon in $Cl_3Si–CH_3$ (l)

16. Two moles of nitrogen gas are heated from 20 ^{o}C to 350 ^{o}C while the volume is kept constant. How does the density of the nitrogen change?

    a. It stays the same.

    b. It increases.

    c. It decreases.

    d. Because nitrogen is a gas, it has zero density.

    e. There is not enough information given to answer the question.

17. What is the concentration of chloride ions in a solution prepared by dissolving 8.3 g of $CoCl_3$ in 125 mL of H_2O?

    a. 0.019 M

    b. 0.050 M

    c. 0.15 M

    d. 0.40 M

    e. 1.2 M

18. Which of the following diagram(s) represents orbital(s) where the quantum number, $\ell = 1$?

(i) (ii) (iii) (iv)

    a) Orbital (i)

    b) Orbital (ii)

    c) Orbitals (i) and (ii)

    d) Orbitals (iii) and (iv)

    e) All of them

19. Which of the classifications below apply to the reaction of copper(II) oxide with hydrogen?

$$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$$

    a) Acid – base

    b) Precipitation

    c) Oxidation reduction (redox)

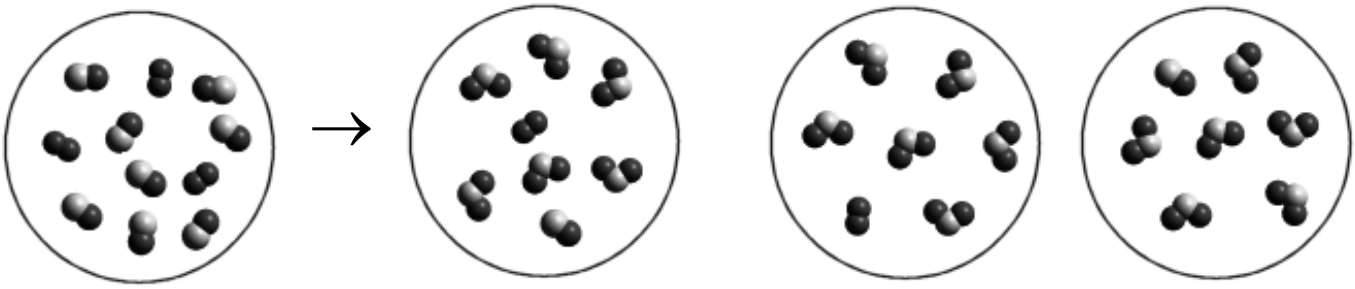
    d) Gas-forming

    e) None of the above

20. Nitric oxide and oxygen react together to form nitrogen dioxide according to the reaction shown below:

$$2NO\ (g)\ +\ O_2(g)\ \rightarrow\ 2\ NO_2\ (g)$$

Consider the initial mixture of reactants shown below. Which of the outcomes shown after the reaction arrow best represents the reaction mixture after the reactants have reacted as completely as possible?



a) b) c)

d) None of the above.

e) Any of the above.

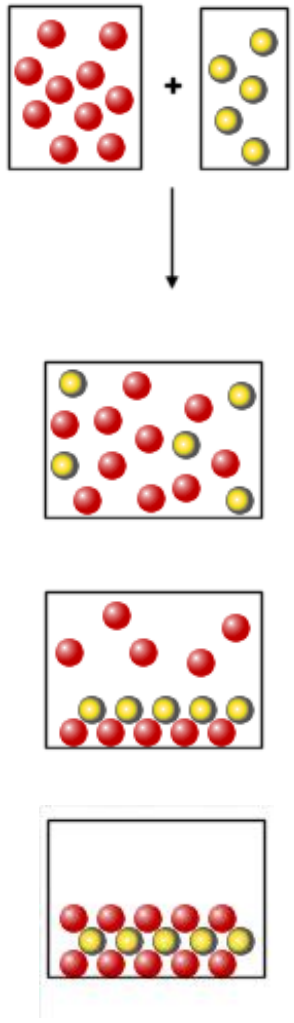
You may use this space for rough work

Section II. The following 6 questions 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:

$Fe_2(SO_4)_3$	_____
Na_2HPO_4	_____
The acid found in vinegar	_____
_____	dichlorine heptoxide
_____	ammonium carbonate
_____	"baking soda"

22. (6 marks) Imagine that an aqueous solution containing a particular cation (dark sphere) is mixed with a solution containing a particular anion (light sphere). Three possible outcomes are shown below the arrow. Which outcome corresponds to each of the following initial mixtures?



(a) $2\ Na^+(aq) + CO_3^{2-}(aq) \rightarrow$

(b) $Ba^{2+}(aq) + CrO_4^{2-}(aq) \rightarrow$

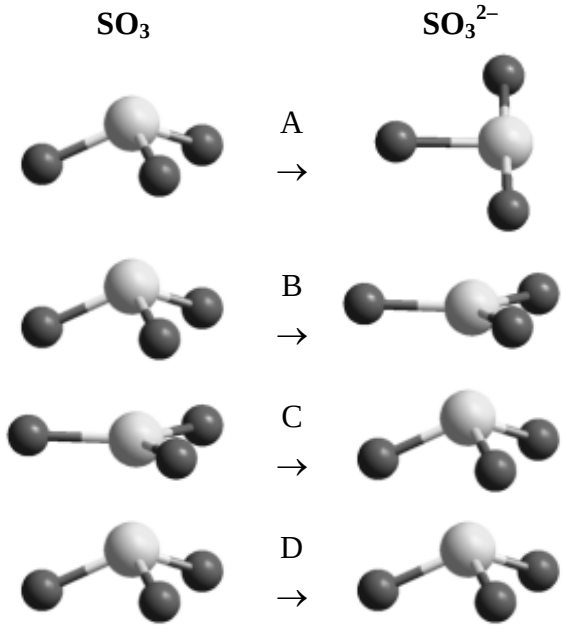
(c) $2\ Ag^+(aq) + S^{2-}(aq) \rightarrow$

Which initial mixture would give the outcome shown to the left?	Explain briefly.

23. (4 marks) Explain why sodium is a strong reducing agent. Provide one example of a balanced equation illustrating this behaviour.

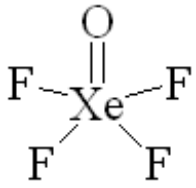
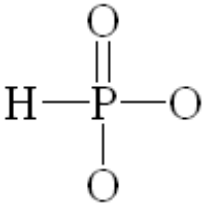
24. (5 marks) When SO_3 gains two electrons, SO_3^{2-} forms.

(a) Which pictures below best illustrates the change in molecular geometry around S? Why?

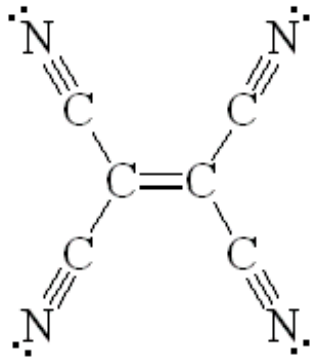


(b) Does molecular polarity change during this reaction? Explain briefly.

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 ***including*** 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 synthesis organic superconducting materials. Its structure is shown below.



a) How many sigma (σ) bonds does it contain (in total)?

b) How many pi (π) bonds does it contain (in total)?

c) Is this molecule polar, or non-polar?

d) Sketch how two p-orbitals overlap to form a π- bond.

Section III. Answer the following 2 problems with *complete* written answers on the exam paper. Use the backs of the pages if you need more space. *Be sure to provide adequate explanations or details to justify your answers*.

27. (8 marks) The foul odour of rancid butter is due largely to butyric acid, a compound containing carbon, hydrogen and oxygen. Combustion analysis of a 4.30 g sample of butyric acid produced 8.59 g of CO_2 and 3.52 g of H_2O. Find the empirical formula of butyric acid.

28. (12 marks) Coal typically contains about 1.6 % sulfur by mass. When coal is burned, the sulfur is converted to sulfur dioxide. To prevent air pollution, coal-burning power plants treat this sulfur dioxide with calcium oxide (CaO) to form calcium sulfite ($CaSO_3$):

$$SO_2(g) + CaO(s) \rightarrow CaSO_3(s)$$

a) Show that the daily mass (in kg) of CaO needed by a power plant that uses 6.60×10^6 kg of coal per day is 1.8×10^5 kg.

b) Without this treatment, what volume of SO_2 gas (at 25 ^oC and 1 atm) would have been emitted into the air per day?

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

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POTENTIALLY USEFUL INFORMATION

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

Electromagnetic radiation	$c = \lambda\cdot\nu$
Energy of photon	$E = h\cdot\nu$
de Broglie's equation	$\lambda = \frac{h}{m\cdot\nu}$
Hydrogen atom	$E = -\frac{R\cdot h\cdot c}{n^2}$
Coulomb's law	$E = (2.13x10^{-19}\ J\cdot nm)\cdot\frac{Q_1\cdot Q_2}{d}$
Ideal gas law	$P\cdot V = n\cdot R\cdot T$
Kinetic energy	$KE = ½\cdot m\cdot v^2$
Maxwell's equation	$\sqrt{\overline{u}^2} = \sqrt{\frac{3\cdot R\cdot T}{M}}$
Graham's law	$\frac{Rate\ of\ effusion\ of\ gas\ 1}{Rate\ of\ effusion\ of\ gas\ 2} = \sqrt{\frac{M\ of\ gas\ 2}{M\ of\ gas\ 1}}$

Periodic Table of the Elements

1																	18
1 **H** 1.008	2											13	14	15	16	17	2 **He** 4.00
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (97.91)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	**La-Lu**	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** 208.98	85 **At** 209.99	86 **Rn** 222.02
87 **Fr** 223	88 **Ra** 226.03	**Ac-Lr**	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.35	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (245)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)