University of Waterloo

AVOGADRO EXAM 2007

UNIVERSITY OF WATERLOO
DEPARTMENT OF CHEMISTRY

17 MAY 2007 **TIME: 75 MINUTES**

This exam is being written by several thousand students. Please be sure that you follow the instructions below. We'll send you a report on your performance. Top performers are eligible for a prize.

1. Print your **name** here: _____

2. Print your **school name** and **city** on your STUDENT RESPONSE sheet.

3. Select, and enter on the STUDENT RESPONSE sheet, one of the following CODE numbers:

Code 1 **Ontario**, now studying Grade 11 Chemistry in a nonsemestered school

Code 2 **Ontario**, now studying Grade 11 Chemistry in a semestered school

Code 3 **Ontario**, Grade 11 Chemistry already completed

Code 4 Any **other Ontario** student

Code 5 **Manitoba or Saskatchewan** high school student

Code 6 **Québec** high school student

Code 7 **not used**

Code 8 **Alberta or British Columbia** high school student

Code 9 **New Brunswick, Newfoundland, Nova Scotia, or Prince Edward Island** high school student

Code 10 **Northwest Territories, Nunavut, or Yukon** high school student

Code 11 High school student **outside Canada**

Code 12 **Teacher**

4. **Print your name** (last name, first name and optional middle initial) **on the STUDENT RESPONSE sheet**. Also fill in the corresponding circles below your printed name.

5. **Carefully detach the last page.** It is the datasheet.

6. Now answer the exam questions. Questions are **not** in order of difficulty. Indicate your choice on the STUDENT RESPONSE sheet by marking one letter beside the question number.
   - Mark only one answer for each question.
   - Questions are all of the same value.
   - **There is a penalty** (1/4 off) for each incorrect answer, but no penalty if you do not answer.

7. Take care that you make firm, **black** pencil marks, just filling the oval.

   Be careful that any erasures are complete—make the sheet white again.

Carefully detach the last page.
It is the Data Sheet.

1 Which of the following has the most neutrons?

A ^{18}F

B ^{18}O

C ^{14}C

D ^{15}N

E ^{11}B

2 Which of the following pairs of atomic symbols and elements is incorrect?

A Al - Aluminium

B Mg - Magnesium

C Ca - Calcium

D Br - Boron

E Mn - Manganese

3 Which of the following is not a subatomic particle?

A α-particle

B β-particle

C electron

D proton

E neutron

4 X_2O is the symbol of a compound. Which of the following is X <u>least</u> likely to be?

A magnesium (Mg)

B sodium (Na)

C cesium (Cs)

D hydrogen (H)

E copper (Cu)

5 How many protons are there in the nucleus of ^{127}I?

A 7

B 53

C 74

D 127

E 190

6 Which group of elements has the greatest electron affinity?

A group 14

B group 15

C group 16

D group 17

E group 18

7 The difference between deuterium $^{2}_{1}H$ and the more common form hydrogen is

A that deuterium does not occur naturally.

B that deuterium is radioactive.

C has one more neutron in the nucleus.

D has one more proton in the nucleus.

E has one more atom per molecule.

8 Which group of atoms and ions contain the same number of electrons?

A F, Ne, Na

B O^{2-}, S^{2-}, Se^{2-}

C Mg, Al, Si

D Ca^{2+}, Fe^{3+}, Zn^{2+}

E Cl^{-}, Ar, K^{+}

9 Which of the following is an ionic solid?

A N_2O

B HCl

C CO_2

D LiCl

E CH_4

10 What volume of CO_2 is produced when you burn exactly 1.0 litre of gaseous propane (C_3H_8) in the presence of excess oxygen in your backyard barbecue? Assume H_2O and CO_2 are the only combustion products and P and T remain constant.

A 1.0

B 1.5

C 2.0

D 2.5

E 3.0

11 Radioactive Polonium ^{210}P is extremely toxic. Complete the reaction for the radioactive decay of ^{210}P.

$$P \rightarrow \boxed{?} + {}^{4}_{2}He$$

A ^{206}Pb

B ^{212}Tl

C ^{214}Po

D ^{214}Rn

E ^{210}Po

12 The bubbles in boiling water are mostly

A He

B H_2O

C CO_2

D N_2

E O_2

13 An element, X, from group 1 of the periodic table combines to form a stable compound with an element, Y, from group 16. The formula of that compound is most likely to be

A X_2Y

B X_2Y_3

C XY

D X_2Y

E XY_3

14 After a large meal the pH of your stomach drops to 1.76. What is the $[H^+]$ in your stomach?

A 1.66×10^{-2} mol L^{-1}

B 60.3 mol L^{-1}

C 1.78 mol L^{-1}

D 1.83×10^{-3} mol L^{-1}

E 6.03×10^{-2} mol L^{-1}

15 $Ba(ReO_4)_2$ is barium perrhenate. What is the charge on the perrhenate ion?

A +2

B +1

C 0

D -1

E -2

16 These three compounds have been isolated: NaCl, Na_2O, and $AlCl_3$. What is the formula of aluminium oxide?

?

A Al_2O

B Al_2O_3

C Al_3O

D AlO

E AlO_3

17 The average car in Canada uses 0.93L of gasoline to go 100km. The density of gasoline, octane, is 0.70g/mL and the molar mass is 114.2 g/mol. How many moles of gasoline are consumed by driving 100km?

A 0.93

B 11

C 5.7

D 5.7×10^{-4}

E 1.1×10^{-3}

18 How many moles of an ideal gas are present in a 15.0L scuba tank with a pressure of 23.0MPa at 298K?

A 23

B 72

C 44

D 14.1

E 139

19 Chlorine has two abundant stable isotopes 35Cl and 37Cl with atomic masses of 34.97 amu and 36.96amu respectively. What is ther percent abundance of the heavier isotope?

A 78

B 36

C 64

D 50

E 24

20 The property of a compound that is closely related to the heat of vapourisation is…?

A density

B colour

C solubility

D thermal stabilty

E boiling point

21 Which of the following types of radiation has the highest energy?

A radio waves

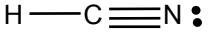
B ultraviolet radiation

C infrared radiation

D x-rays

E purple laser light

22 The Lewis structure (i.e. electron dot) structure for the O_3 molecule is given below.



The bond angle is nearest to

A 60^o

B 90^o

C 105^o

D 120^o

E 180^o

23 What volume of $0.100 mol L^{-1}$ NaOH is required to neutralize 0.245L of $0.200 mol L^{-1}$ H_3PO_4?

A 0.490 L

B 0.500 L

C 1.47 L

D 2.30 L

E 1.47 mL

24 Which of the following compounds forms hydrogen bonds?

A CH_3OCH_3 Dimethyl ether

B HCl Hydrochloric acid

C H_2S Hydrogen sulfide

D CH_3CH_2OH Ethanol

E H_2CO Formaldehyde

25 Al(s) dissolves in acidic solution according to the following reaction

$2Al(s) + 6HCl \rightarrow 2AlCl_3 + 3H_2(g)$

How many grams of aluminium (27g/mol) are necessary to produce 0.50mol of $H_2(g)$?

A 20

B 9.0

C 14

D 27

E .24

26 For which of the following reactions is the change in energy equal the first electron affinity?

A $X^-(g) + e^- \rightarrow X^{2-}(g)$

B $X(g) + 2e^- \rightarrow X^{2-}(g)$

C $X(g) \rightarrow X^+ + e^-$

D $X(g) + e^- \rightarrow X^-(g)$

E $X(g) \rightarrow X^{2+} + 2e^-$

27 How does the pH of a solution change as HCl is added to a solution of NaOH?

A The pH decreases and may go below 7.

B The pH will not change.

C The pH decreases until it reaches a value of 7 and the stops.

D The pH increases until it reaches a value of 7 and then stops.

E The pH increases and may go above 7.

28 The volume of a gas at 1 atm temperature of 20 C is increased from 40mL to 80mL. If the pressure remains constant what is the final temperature of the gas?

A $293K + \frac{80.0}{40.0}$

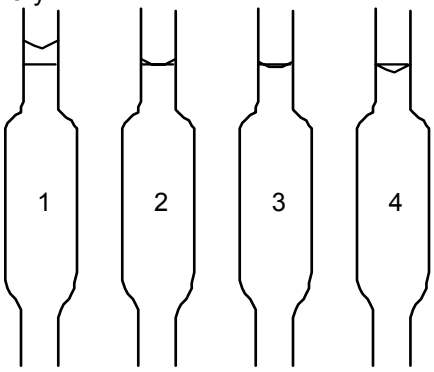
B $20^\circ C \times \frac{80.0}{40.0}$

C $293K \times \frac{80.0}{40.0}$

D $293K \times \frac{40.0}{80.0}$

E $20^\circ C \times \frac{40.0}{80.0}$

29 Which drawing shows a pipet correctly filled for delivery?



A 1

B 2

C 3

D 4

E none of the above

30 What is the mass percent copper in $Cu(II)Cl_2$?

A 12.1%

B 64.2%

C 91.2%

D 25.2%

E 47.3%

31 Which one of the following solutions will be the best electrical conductor at 25°C?

A 0.10 mol L^{-1} $Na_2SO_4(aq)$

B 0.10 mol L^{-1} $NaCl(aq)$

C 0.10 mol L^{-1} $CaSO_4(aq)$

D 0.10 mol L^{-1} $HNO_3(aq)$

E 0.10 mol L^{-1} $CsCl(aq)$

32 What is the coefficient of O_2 when the following reaction is balanced with whole-number coefficients?

$\_\_Cr_2O_3 + \_\_\_ KOH + \_\_\_O_2 \rightarrow \_\_K_2CrO_4 + \_\_H_2O$

A 2

B 3

C 4

D 5

E 6

33 What is the oxidation state of N in HNO_2?

A +5

B +3

C +1

D −1

E −3

34 If the kelvin temperature of a sample of ideal gas doubles (e.g. from 200 K to 400 K), then the average kinetic energy of the molecules in the sample

A increases by a factor of $\sqrt{2}$

B increases by a factor of 2

C decreases by a factor of 2

D increases by a factor of 4

E remains the same

35 A neutral atom whose lowest electronic configuration is [Xe] $6s^2$ $5f^{14}$ $6d^{10}$ $6p^4$ belongs to …..

A Group 3

B Group 4

C Group 6

D Group 14

E Group 16

36 How many moles of water are there in 1.80L of $H_2O(l)$ at a pressure of 1.00 atm and temperature of 298K. The density of water is 1.00g/mL.

A 1.00

B .0736

C 55.6

D 1.00×10^2

E 13.6

37 The reaction, $Al(s) + HCl(aq) \rightarrow AlCl_3(aq) + H_2(g)$ is an example of

A a precipitation reaction

B an acid-base reaction

C a decomposition reaction

D an oxidation-reduction reaction

E an isomerization reaction

38 If equal volumes of 0.10 mol/L solutions of NaOH and HCl are mixed, what is the pH of the solution?

A 1

B 13

C 7

D 1.3

E 12.7

39 What is the concentration of a calcium chloride solution if 11.00 g of calcium chloride, $CaCl_2$, is dissolved in water to make 500 mL of solution?

A .2 $molL^{-1}$

B .1982 $molL^{-1}$

C .198 $molL^{-1}$

D .2000 $molL^{-1}$

E .20 $molL^{-1}$

40 A compound of carbon and hydrogen is found to be 85.6 % carbon, by mass, and 14.38% hydrogen. What is the simplest formula of the compound?

A CH

B CH_2

C CH_3

D CH_4

E C_3H_4

DATA SHEET
AVOGADRO EXAM 2007

DETACH CAREFULLY

1 1A																	18 8A
1 **H** 1.008	2 **2A**											13 **3A**	14 **4A**	15 **5A**	16 **6A**	17 **7A**	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3 **3B**	4 **4B**	5 **5B**	6 **6B**	7 **7B**	8 **←**	9 **8B**	10 **→**	11 **1B**	12 **2B**	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** 47.88	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** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	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** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226	89 **Ac** 227.0	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110 **Uun**	111 **Uuu**	112 **Uub**	113 **Uut**					

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.00	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	94 **Pu** (244)	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)

Constants:

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

R = 0.082058 atm L K^{-1} mol^{-1}

= 8.3145 kPa L K^{-1} mol^{-1}

= 8.3145 J K^{-1} mol^{-1}

K_w = 1.0×10^{-14} (at 298 K)

F = 96 485 C mol^{-1}

Conversion factors:

1 atm = 101.325 kPa = 760 torr = 760 mm Hg

0°C = 273.15 K

Equations: $PV = nRT$ $k\,t_{1/2} = 0.693$ $\text{pH} = \text{p}K_a + \log\left([\text{base}]/[\text{acid}]\right)$ $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$