

15 MAY 2008

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. The names of the top 200 students will be published in the September issue of Chem 13 News.*

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 elements is **not** a metal?
- A Se  
B Sn  
C Sr  
D Sc  
E Cs
- 2 A colourless, odourless gas is thought to be oxygen. Which of the following experimental results would support this conclusion?
- A Burning the gas in air produces only water.  
B The gas extinguishes a flame.  
C The gas turns a  $\text{Ca}(\text{OH})_2$  solution milky.  
D A glowing piece of wood bursts into flames in the gas.  
E The gas tarnishes silver.
- 3 Which of the following particles is the most massive?
- A  $\alpha$ -particle  
B  $\beta$ -particle  
C electron  
D proton  
E neutron
- 4 What volume of  $5.0 \text{ mol L}^{-1} \text{H}_2\text{SO}_4(\text{aq})$  must be diluted with water to make  $1.00 \text{ L}$  of  $0.45 \text{ mol L}^{-1} \text{H}_2\text{SO}_4(\text{aq})$ ?
- A  $0.090 \text{ L}$   
B  $0.44 \text{ L}$   
C  $0.090 \text{ mL}$   
D  $0.045 \text{ L}$   
E  $2.22 \text{ mL}$
- 5 How many neutrons are there in the nucleus of  $^{131}\text{I}$ ?
- A 44  
B 53  
C 78  
D 131  
E 184
- 6 Which group of elements contains no metals or metalloids?
- A group 13  
B group 14  
C group 15  
D group 16  
E group 17
- 7 Which of these chloride salts is least likely to exist?
- A  $\text{NaCl}$   
B  $\text{CuCl}$   
C  $\text{CaCl}_2$   
D  $\text{FeCl}_3$   
E  $\text{MgCl}$
- 8 When a sample of atomic hydrogen gas is heated, it emits violet, blue, green and red light. Which of the following statements best explains this observation?
- A The energy of the electron in a hydrogen atom is restricted to certain values.  
B The energy of the electron in a hydrogen atom is not restricted in any way.  
C The electron in a hydrogen atom is restricted to one of only four possible circular orbits.  
D The distance between the electron and the nucleus in a hydrogen atom is restricted to certain values.  
E none of the above

9 Which of the following is **not** a mixture?

- A seawater
- B table sugar
- C brass
- D cement
- E smoke

10 Radioactive  $^{131}\text{I}$  is used to treat thyroid cancer. An incomplete chemical equation for the radioactive decay of  $^{131}\text{I}$  is given below.



What is the missing product in the equation above?

- A  $^{130}\text{I}$
- B  $^{129}\text{I}$
- C  $^{131}\text{Xe}$
- D  $^{131}\text{Te}$
- E  $^{131}\text{I}^+$

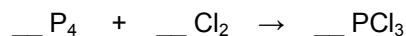
11 Which of the following has the highest concentration in air at STP?

- A He
- B  $\text{H}_2\text{O}$
- C  $\text{CO}_2$
- D  $\text{N}_2$
- E  $\text{O}_2$

12 The average mass of a solid copper penny is 2.63 g. What is the mass of one mole of pennies?

- A  $1.58 \times 10^{24}$  g
- B  $6.02 \times 10^{23}$  g
- C  $6.36 \times 10^{23}$  g
- D 63.6 g
- E  $1.58 \times 10^{23}$  g

13 What is the sum of the coefficients when the following equation is balanced using the smallest whole number coefficients?



- A 12
- B 11
- C 6
- D 5
- E 3

14 How many litres of gaseous methane ( $\text{CH}_4$ ) must be burned in oxygen to produce enough  $\text{H}_2\text{O}$  and  $\text{CO}_2$  to fill a 3.0-L balloon? Assume that  $\text{H}_2\text{O}$  and  $\text{CO}_2$  are the only combustion products and that the temperature and pressure remain constant.

- A 1.0 L
- B 1.5 L
- C 2.0 L
- D 2.5 L
- E 3.0 L

15 A compound that contains only Fe and O is 69.9% Fe by mass. What is the empirical formula of this compound?

- A FeO
- B  $\text{FeO}_2$
- C  $\text{Fe}_2\text{O}_3$
- D  $\text{Fe}_2\text{O}$
- E  $\text{Fe}_3\text{O}_4$

- 16 If 17.0 grams of sodium chloride are dissolved in water to make 0.5 L of solution, then what is the final concentration of the solution? Give your answer with the correct number of significant figures.
- A 0.6 mol L<sup>-1</sup>  
B 0.58 mol L<sup>-1</sup>  
C 0.581 mol L<sup>-1</sup>  
D 0.3 mol L<sup>-1</sup>  
E 0.291 mol L<sup>-1</sup>
- 17 What is the effect of adding a catalyst to a reaction mixture?
- A It increases the equilibrium concentrations of the products.  
B It decreases the enthalpy change of the reaction.  
C It reduces the activation energy of the reaction.  
D It increases the value of the equilibrium constant for the reaction.  
E It increases the time it takes for the reaction to reach equilibrium.
- 18 How many valence electrons are there in one Al<sup>3+</sup> ion?
- A 2  
B 4  
C 6  
D 8  
E 10
- 19 What volume of He(g) contains the same number of moles of gas as 1.00 L of N<sub>2</sub>(g) at the same temperature and pressure?
- A 7.00 L  
B 1.00 L  
C 0.143 L  
D 35.7 mL  
E 4.00 L
- 20 What is the HNH bond angle in an ammonia (NH<sub>3</sub>) molecule? Choose the closest value.
- A 90°  
B 45°  
C 120°  
D 109°  
E 180°
- 21 Which of the following types of radiation has the lowest energy per photon?
- A radio waves  
B ultraviolet radiation  
C infrared radiation  
D x-rays  
E purple laser light
- 22 An incomplete Lewis structure (i.e. electron dot structure) for the O<sub>3</sub> molecule is given below.
- O — O — O
- How many lone pairs of electrons are there in the completed structure?
- A two  
B four  
C five  
D six  
E eight
- 23 Which of the following is not a common oxide of nitrogen?
- A NO  
B NO<sub>2</sub>  
C N<sub>2</sub>O<sub>4</sub>  
D N<sub>2</sub>O  
E NO<sub>3</sub>

- 24 In an experiment, 0.12 L of 0.10 mol L<sup>-1</sup> H<sub>2</sub>SO<sub>4</sub>(aq) and 0.20 L of 0.10 mol L<sup>-1</sup> NaOH(aq) are combined. Which of the following statements is **true**?
- A The pH of the resulting solution is less than 7.
  - B The pH of the resulting solution is greater than 7.
  - C The pH of the resulting solution is close to 7.
  - D The pH of the resulting solution is exactly 7.
  - E None of the statements above are true.
- 25 Solid aluminum dissolves in hydrochloric acid solution according to the following chemical equation.
- $$2 \text{Al}(s) + 6 \text{HCl}(aq) \rightarrow 2 \text{AlCl}_3(aq) + 3 \text{H}_2(g)$$
- How many moles of H<sub>2</sub> are produced if 17.5 moles of Al are added to a solution containing 24.8 moles of HCl?
- A 26.3 mol
  - B 12.4 mol
  - C 7.30 mol
  - D 17.5 mol
  - E 24.8 mol
- 26 Which of the following choices does **not** involve a chemical change?
- A evaporation and neutralization
  - B neutralization and sublimation
  - C oxidation and sublimation
  - D evaporation and sublimation
  - E neutralization and oxidation
- 27 Which of the following atoms or ions has the electron configuration 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>1</sup> in its ground electronic state?
- A Na<sup>-</sup>
  - B Mg<sup>+</sup>
  - C K
  - D Ca<sup>+</sup>
  - E Al<sup>3+</sup>
- 28 Which of the following is a brittle solid and an electrical insulator at room temperature, but an excellent electrical conductor in its liquid form?
- A sulphur
  - B sodium chloride
  - C aluminum
  - D mercury
  - E carbon
- 29 Which of the following salts produces a basic solution when it is dissolved in water?
- A KCl
  - B NH<sub>4</sub>Cl
  - C K<sub>2</sub>CO<sub>3</sub>
  - D NaNO<sub>3</sub>
  - E CuBr<sub>2</sub>
- 30 Which of the following describes the process that produces Fe(s) from Fe<sub>2</sub>O<sub>3</sub>(s)?
- A combustion
  - B precipitation
  - C hydrolysis
  - D reduction
  - E oxidation

- 31 Which one of the following solutions will be the worst electrical conductor at 25°C?
- A 0.10 mol L<sup>-1</sup> Na<sub>2</sub>SO<sub>4</sub> (aq)
  - B 0.10 mol L<sup>-1</sup> NaCl(aq)
  - C 0.10 mol L<sup>-1</sup> CaSO<sub>4</sub>(aq)
  - D 0.10 mol L<sup>-1</sup> CH<sub>3</sub>OH(aq)
  - E 0.10 mol L<sup>-1</sup> CsCl(aq)
- 32 Which of the following atoms is **not** present in large numbers in biological molecules?
- A C
  - B F
  - C O
  - D N
  - E H
- 33 In which of these compounds is the oxidation state of Cl the highest?
- A HClO<sub>2</sub>
  - B ClO<sub>2</sub>
  - C Cl<sub>2</sub>O<sub>5</sub>
  - D Cl<sub>2</sub>O
  - E HClO<sub>4</sub>
- 34 Which of the gases most closely resembles an ideal gas at standard temperature and pressure?
- A CO<sub>2</sub>
  - B NH<sub>3</sub>
  - C HI
  - D H<sub>2</sub>
  - E H<sub>2</sub>O
- 35 Which of the following have ground state electron configurations of the type ns<sup>2</sup> np<sup>2</sup> ?
- A group 2 atoms
  - B group 4 atoms
  - C group 6 atoms
  - D group 14 atoms
  - E group 16 atoms
- 36 Which of the species in the reaction below are Brønsted-Lowry acids?
- $$\text{HSO}_4^- + \text{HCO}_3^- \rightleftharpoons \text{SO}_4^{2-} + \text{H}_2\text{CO}_3$$
- A HSO<sub>4</sub><sup>-</sup> and HCO<sub>3</sub><sup>-</sup>
  - B HSO<sub>4</sub><sup>-</sup> and H<sub>2</sub>CO<sub>3</sub>
  - C HCO<sub>3</sub><sup>-</sup> and SO<sub>4</sub><sup>2-</sup>
  - D SO<sub>4</sub><sup>2-</sup> and H<sub>2</sub>CO<sub>3</sub>
  - E HSO<sub>4</sub><sup>-</sup> and SO<sub>4</sub><sup>2-</sup>
- 37 Which of the following is **not** an alkane?
- A C<sub>2</sub>H<sub>4</sub>
  - B C<sub>3</sub>H<sub>8</sub>
  - C C<sub>4</sub>H<sub>10</sub>
  - D C<sub>5</sub>H<sub>12</sub>
  - E C<sub>6</sub>H<sub>14</sub>

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**38** What happens when a solution of lithium chloride (LiCl) and a solution of ammonium nitrate ( $\text{NH}_4\text{NO}_3$ ) are mixed?

- A A precipitate forms.
- B A new salt is formed.
- C A gas is evolved.
- D A metal is formed.
- E No reaction occurs.

**39** An average person expends approximately 100 kJ to walk 1 km. How far will the average car travel by the time it expends the same amount of energy (i.e. 100 kJ) as a person who walked 1 km? Use the data given below to determine the answer. Choose the closest answer.

- A 2 km
- B 0.2 km
- C 0.02 km
- D 20 km
- E 200 km

Fuel consumption of an average car, $8 \text{ km L}^{-1}$
Heat of combustion of gasoline, $50 \text{ kJ g}^{-1}$
Density of gasoline, $0.7 \text{ g mL}^{-1}$

**40** How many structural isomers are there for  $\text{C}_5\text{H}_{12}$ ?

- A less than three
- B three
- C four
- D five
- E more than five

**DATA SHEET  
AVOGADRO EXAM 2008**

**DETACH CAREFULLY**

<b>1 1A</b>																		<b>18 8A</b>	
1 <b>H</b> 1.008												<b>2 He</b> 4.003							
<b>2 2A</b>												<b>13 3A</b>	<b>14 4A</b>	<b>15 5A</b>	<b>16 6A</b>	<b>17 7A</b>			
3 <b>Li</b> 6.941	4 <b>Be</b> 9.012											5 <b>B</b> 10.81	6 <b>C</b> 12.01	7 <b>N</b> 14.01	8 <b>O</b> 16.00	9 <b>F</b> 19.00	10 <b>Ne</b> 20.18		
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31											13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.07	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95		
<b>3 3B</b>		<b>4 4B</b>		<b>5 5B</b>		<b>6 6B</b>		<b>7 7B</b>		<b>8 ←</b>	<b>9 8B</b>		<b>10 →</b>	<b>11 1B</b>		<b>12 2B</b>			
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.88	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.38	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80		
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.9	46 <b>Pd</b> 106.4	47 <b>Ag</b> 107.9	48 <b>Cd</b> 112.4	49 <b>In</b> 114.8	50 <b>Sn</b> 118.7	51 <b>Sb</b> 121.8	52 <b>Te</b> 127.6	53 <b>I</b> 126.9	54 <b>Xe</b> 131.3		
55 <b>Cs</b> 132.9	56 <b>Ba</b> 137.3	57 <b>La</b> 138.9	72 <b>Hf</b> 178.5	73 <b>Ta</b> 180.9	74 <b>W</b> 183.9	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.1	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.6	81 <b>Tl</b> 204.4	82 <b>Pb</b> 207.2	83 <b>Bi</b> 209.0	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)		
87 <b>Fr</b> (223)	88 <b>Ra</b> 226	89 <b>Ac</b> 227.0	104 <b>Rf</b>	105 <b>Db</b>	106 <b>Sg</b>	107 <b>Bh</b>	108 <b>Hs</b>	109 <b>Mt</b>	110 <b>Uun</b>	111 <b>Uuu</b>	112 <b>Uub</b>	113 <b>Uut</b>							

58 <b>Ce</b> 140.1	59 <b>Pr</b> 140.9	60 <b>Nd</b> 144.2	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 152.00	64 <b>Gd</b> 157.3	65 <b>Tb</b> 158.9	66 <b>Dy</b> 162.5	67 <b>Ho</b> 164.9	68 <b>Er</b> 167.3	69 <b>Tm</b> 168.9	70 <b>Yb</b> 173.0	71 <b>Lu</b> 175.0
90 <b>Th</b> 232.0	91 <b>Pa</b> 231.0	92 <b>U</b> 238.0	93 <b>Np</b> 237.0	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)

**Constants:**

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

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

$$= 8.3145 \text{ kPa L K}^{-1} \text{ mol}^{-1}$$

$$= 8.3145 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$K_w = 1.0 \times 10^{-14} \text{ (at 298 K)}$$

$$F = 96\,485 \text{ C mol}^{-1}$$

**Conversion factors:**

$$1 \text{ atm} = 101.325 \text{ kPa} = 760 \text{ torr} = 760 \text{ mm Hg}$$

$$0^\circ\text{C} = 273.15 \text{ K}$$

**Equations:**

$$PV = nRT$$

$$k_{t_{1/2}} = 0.693$$

$$\text{pH} = \text{pK}_a + \log \left( \frac{[\text{base}]}{[\text{acid}]} \right)$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$