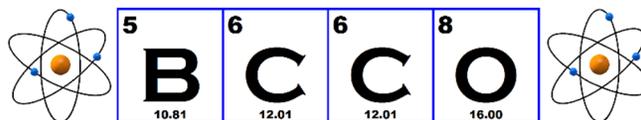


# JUNIOR CANADIAN CHEMISTRY OLYMPIAD

## British Columbia Chemistry Olympiad



2019

*The Periodic Table/Data Sheet may be used for all parts of the contest, and non-programmable calculators are allowed.*

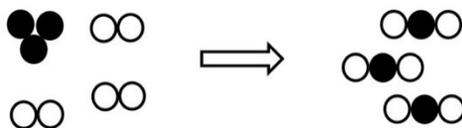
*Write your answers on the back side of the Answer Sheet provided. Do not forget to write your name and your school name on the front of the Answer Sheet. While students are expected to attempt all questions for a complete examination in 1.5 hours, it is recognized that backgrounds will vary and students will not be eliminated from further competitions because they have missed parts of the paper.*

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- 
- Which of the following chemical equations is properly balanced?
    - $\text{CH}_3\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
    - $2\text{NaOH} + \text{H}_3\text{PO}_4 \rightarrow \text{Na}_2\text{HPO}_4 + \text{H}_2\text{O}$
    - $\text{Ba}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + \text{NaNO}_3$
    - $\text{C}_6\text{H}_8 + 8\text{O}_2 \rightarrow 6\text{CO}_2 + 4\text{H}_2\text{O}$
    - $3\text{NaOH} + \text{H}_3\text{PO}_4 \rightarrow \text{Na}_3\text{PO}_4 + 2\text{H}_2\text{O}$
  - Camphor ( $\text{C}_{10}\text{H}_{16}\text{O}$ ) is a terpenoid with a strong aroma found in camphor trees leaves. If an average of 45.6 mg of camphor can be extracted from leaf of camphor tree, how many moles of camphor can be extracted from 100 camphor tree leaves?
    - $4.56 \times 10^{-2}$
    - $3.00 \times 10^{-2}$
    - $3.00 \times 10^{-3}$
    - $4.56 \times 10^1$
    - $3.00 \times 10^{-1}$
  - Calculate the mass of anhydrous sodium bisulfate ( $\text{NaHSO}_4$ ) required to prepare a 0.10 M bisulfate solution in water using a 100 mL volumetric flask.
    - 1.19 g
    - 1.04 g
    - 11.9 g
    - 1.20 g
    - 0.12 g
  - In order to plot a two component phase diagram, 0.527 g of naphthalene (128.174 g/mol) and 1.264 g of diphenylamine (169.227 g/mol) are mixed and melted together. What is the mole fraction of naphthalene in the mixture?
    - 0.550
    - 0.645
    - 0.355
    - 0.450
    - 0.569
  - The first law of Thermodynamics states that
    - Entropy is zero for a perfect crystal of a pure substance at zero Kelvin.
    - The entropy of a system increases for any spontaneous process.
    - An object maintains its state of motion unless acted upon by an unbalanced force.
    - Heat flows spontaneously from a hot body to a cold body.
    - Energy is conserved

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- 6) What is the balanced form of the chemical reaction depicted below?

Element A: ●  
Element B: ○



- a)  $A_3 + 3B_2 \rightarrow 3AB_2$   
 b)  $3A + 3B_2 \rightarrow 3AB_2$   
 c)  $3A + 6B \rightarrow 3AB_2$   
 d)  $3A + 6B \rightarrow A_3B_6$   
 e)  $A_3 + B_2 \rightarrow AB_2$
- 7) The density of ethanol ( $C_2H_5OH$ ) at  $20\text{ }^\circ\text{C}$  is  $0.7893\text{ g/cm}^3$ . What is the volume of 1 mole of ethanol at  $20\text{ }^\circ\text{C}$ ?
- a) 46.1 mL    **b) 58.4 mL**    c) 36.4 mL    d) 0.584 L    e)  $46.1\text{ m}^3$
- 8) Which of the following accurately represents a trend in electronegativity?
- a)  $Ne > F > O$   
**b)  $F > O > N$**   
 c)  $Br > Cl > F$   
 d)  $Cs > Rb > Na$   
 e)  $Al > P > S$
- 9) Which of the following accurately represents a trend in the first ionization energies?
- a)  $Ne > F > C$**   
 b)  $Br > Cl > F$   
 c)  $Cs > Rb > Na$   
 d)  $Ar > Ne > He$   
 e)  $Al > P > S$

- 10) The second law of Thermodynamics states that

- a) Entropy is zero for a perfect crystal of a pure substance at zero Kelvin.  
 b) The entropy of a system increases for any spontaneous process.  
 c) An object maintains its state of motion unless acted upon by an unbalanced force.  
**d) The entropy of the universe is continually increasing.**  
 e) Energy is conserved.

- 11) To study weather phenomena sensors carried by balloons are used. What is the mass of helium that is needed to fill a  $65\text{ m}^3$  balloon to a pressure of 1 atm at  $25\text{ }^\circ\text{C}$ ? Assume ideal gas behavior.

- a) 2.66 kg    b) 0.105 g    c) 11.61 g    **d) 10.63 kg**    e) 126.8 kg

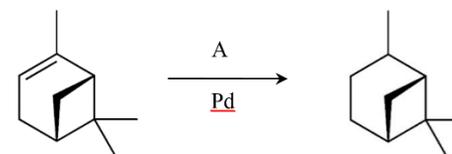
- 12)  $\alpha$ -Pinene is a terpenoid with a strong aroma found in pine resin.

Which of the following molecular formula is the correct one for  $\alpha$ -pinene?

- a)  $C_9H_{11}$     b)  $C_{10}H_{14}$     **c)  $C_{10}H_{16}$**     d)  $C_9H_{14}$     e)  $C_9H_{16}$



- 13)  $\alpha$ -Pinene is a reactant in the following reaction:



Which of the following compounds could be used as reagent A?

- a) HCl    **b)  $H_2$**     c)  $O_3$     d)  $H_2O$     e)  $NaHCO_3$

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- 14) A solution of tetrachloroethane ( $C_2H_2Cl_4$ ) in cyclohexanone ( $C_6H_{10}O$ ) is prepared with 29.3 mL of tetrachloroethane in 86.5 mL of cyclohexanone. What is the mole fraction of tetrachloroethane in the solution? Assume densities of  $1.59 \text{ g/cm}^3$  for tetrachloroethane and  $0.948 \text{ g/cm}^3$  for cyclohexanone.

a) 0.249    b) 0.165    c) 0.751    d) 0.835    e) 0.181

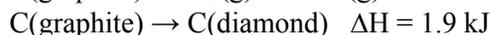
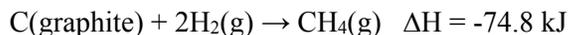
- 15) A catalyst cannot alter.

a) the rate of a reaction.  
 b) the activation energy of a reaction.  
 c) the equilibrium constant of a reaction.  
 d) the half-life of a reaction.  
 e) the rate constant of a reaction.

- 16)  $^{14}C$  is eliminated from the body of a dead mammoth by a first order process that has a half-life of 5750 years. What percentage of the initial  $^{14}C$  would remain in the mammoth body after 11 500 years?

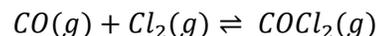
a) 0%    b) 25%    c) 50%    d) 75%    e) 2%

- 17) Consider the following reaction:  $CH_4(g) \rightarrow C(\text{diamond}) + 2H_2(g)$ . Use the information provided below to calculate the enthalpy of reaction when 1 mole of diamond is formed.



a) -76.7 kJ    b) 72.9 kJ    c) 76.7 kJ    d) -72.9 kJ    e) 74.8 kJ

- 18) The highly toxic carbonyl chloride (phosgene) is used to synthesize many organic compounds:



The equilibrium constant  $K_p$  for the gas-phase synthesis of phosgene is 7.70 at  $75^\circ C$ . What is the equilibrium pressure of  $COCl_2$  if the equilibrium pressures of  $CO$  and  $Cl_2$  are both 2 atm?

a) 1.90 atm    b) 15.4 atm    c) 30.8 atm    d) 3.90 atm    e) 237 atm

- 19) The rate law for the above reaction is as follows:  $v = k[CO][Cl_2]^x$ . Use the data table below to find the value of x.

Experiment	Initial concentration (M)		Initial rate ( $M s^{-1}$ )
	[CO]	[Cl <sub>2</sub> ]	
1	0.12	0.20	0.121
2	0.24	0.40	0.684

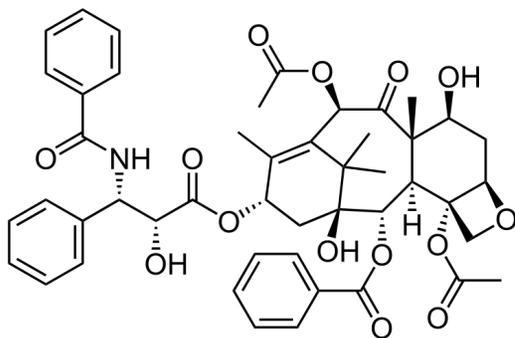
a) 1.0    b) 0.5    c) 0    d) 2.0    e) 1.5

- 20) When 7.41 g of solid  $Ca(OH)_2$  (Molar mass = 74.09 g/mole,  $K_{sp} = 5.02 \times 10^{-6}$ ) is dissolved into 1.00 L of water (assume there is no change in volume), the pH of the solution is closest to,

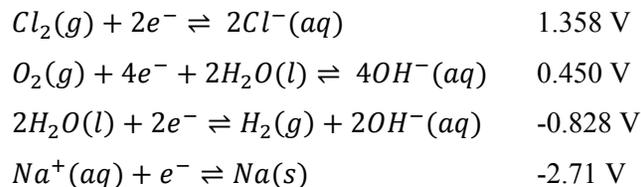
a) 13.00    b) 12.67    c) 12.33    d) 12.00    e) 11.67

## JUNIOR CANADIAN CHEMISTRY OLYMPIAD

- 21) Taxol is a natural product isolated from the Pacific Yew tree in the north western part of the province of British Columbia and has been used as a drug in the treatment of a few types of cancers. The structure of Taxol molecule is shown on the right. Based on the structure, a Taxol molecule contains the following functional groups,



- a) Alcohol, Aldehyde, Amide, Ester, Ketone  
**b) Alcohol, Amide, Ester, Ether, Ketone**  
 c) Alcohol, Aldehyde, Amine, Ester, Ether  
 d) Alcohol, Amine, Ketone, Ester, Ether  
 e) Alcohol, Aldehyde, Amide, Ester
- 22) Household bleach can be produced by the electrolysis of sea water. Given the standard reduction potential as follows,



What is produced at the negative electrode during the electrolysis of sea water?

- a)  $\text{Cl}_2(g)$    b)  $\text{O}_2(g)$    c)  $\text{Na}(s)$    **d)  $\text{H}_2(g)$**    e)  $\text{NaClO}(s)$

- 23) Which of the following is ranked correctly based on the increasing melting point under the standard atmospheric pressure?

- a)  $\text{F}_2 < \text{Ga} < \text{CH}_3\text{CH}_2\text{OH} < \text{NaCl} < \text{SiO}_2$   
 b)  $\text{F}_2 < \text{CH}_3\text{CH}_2\text{OH} < \text{Ga} < \text{SiO}_2 < \text{NaCl}$   
 c)  $\text{F}_2 < \text{CH}_3\text{CH}_2\text{OH} < \text{NaCl} < \text{SiO}_2 < \text{Ga}$   
 d)  $\text{F}_2 < \text{Ga} < \text{CH}_3\text{CH}_2\text{OH} < \text{SiO}_2 < \text{NaCl}$   
**e)  $\text{F}_2 < \text{CH}_3\text{CH}_2\text{OH} < \text{Ga} < \text{NaCl} < \text{SiO}_2$**

- 24) Based on the VSEPR theory, in how many of the following molecular geometries are all atoms lay on the same plane?

- Linear  
 Trigonal planar  
 Bent  
 T-shape  
 Square planar

- a) 1      b) 2      c) 3      d) 4      **e) 5**

- 25) What will be the pH of a solution prepared by mixing 100 mL of 0.50 M acetic acid with 50 mL of 0.50 M NaOH?

The  $K_a$  of acetic acid is  $1.8 \times 10^{-5}$ .

- a) 4.74**      b) 9.26      c) 2.76      d) 8.99      e) 5.01

*End of examination questions.*

