



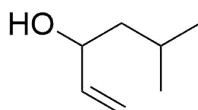
# SwissChO

## First Round SwissChO 2018

### Information

- This exam should be solved within approximately one hour, using only books and a calculator. The answers should be copied to the separate answer sheet using a dark felt tip pen or ballpoint pen.
- It is possible that more than one answer is correct.
- Following the IChO regulations, students are eligible to participate if they:
  - were born on July 1<sup>st</sup> 1997 or later,
  - are not enrolled at a university,
  - are or have been attending a Swiss school.
- Answers have to be submitted before October 15<sup>th</sup> 2017.
- You can also enter the answers on our homepage <http://www.swisscho.ch>.

1. What is the oxidation state of molybdenum in the ion  $[\text{Mo}_2\text{O}_4(\text{NCS})_6]^{4-}$ ?
- A. +II      B. +III      C. +IV      D. +V      E. +VI
2. Which one of the following best describes the molecular geometry (shape) of  $\text{H}_2\text{Te}$ ?
- A. bent  
B. linear  
C. square planar  
D. trigonal bipyramidal  
E. tetrahedral
3. An oxide of nitrogen contains 63.65 mass-% nitrogen. Which one is the correct compound?
- A. NO      B.  $\text{NO}_2$       C.  $\text{N}_2\text{O}$       D.  $\text{N}_2\text{O}_5$
4. Which of the following gives a basic solution when dissolved in water?
- A.  $\text{Ba}(\text{NO}_3)_2$     B.  $\text{NaNO}_2$     C. KBr      D.  $\text{NH}_4\text{I}$       E.  $\text{ZnCl}_2$
5. Calculate the pH of a 0.1 M acetic acid solution ( $\text{p}K_a = 4.75$ ).
- A. pH = 3.2    B. pH = 11.1    C. pH = 10.8    D. pH = 2.9    E. pH = 1
6. The solubility product of  $\text{CaSO}_4$  is  $K_L = 4.93 \cdot 10^{-5} \frac{\text{mol}^2}{\text{L}^2}$ . How much  $\text{CaSO}_4$  can be dissolved in 1 L of a 0.2 M  $\text{Na}_2\text{SO}_4$  solution?
- A.  $2.47 \cdot 10^{-5} \text{ g}$   
B.  $3.36 \cdot 10^{-2} \text{ g}$   
C.  $7.00 \cdot 10^{-3} \text{ g}$   
D.  $9.56 \cdot 10^{-1} \text{ g}$   
E. 2.14 g
7. How many constitutional isomers exist for the sum formula  $\text{C}_4\text{H}_{10}\text{O}$ ?
- A. 7      B. 9      C. 6      D. 8      E. 12
8. How is the following structure named according to the nomenclature rules from IUPAC?

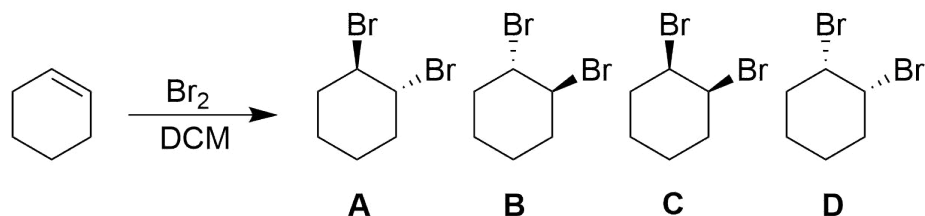


- A. 5-Methylhex-4-ol-1-en  
B. 1-Vinyl,3-methylhexan-1-ol  
C. 2-Methylhex-5-en-3-ol  
D. (E)-1-Methylhept-5-en-4-ol  
E. 5-Methylhex-1-en-3-ol

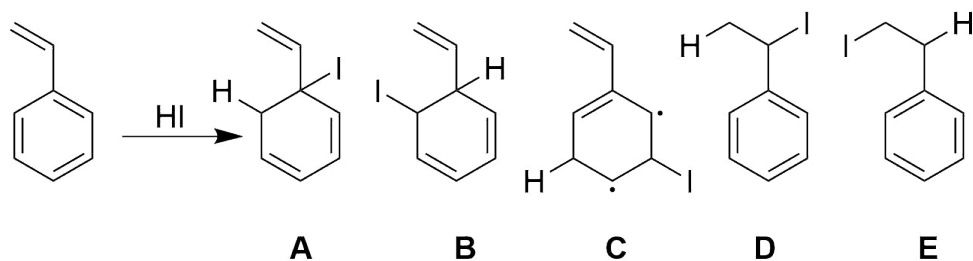
9. The molecules listed below have the general formula  $XY_n$ . Which one of the following compounds has the largest Y–X–Y bond angle?

- A.  $BF_3$       B.  $SCl_2$       C.  $CH_4$       D.  $NH_3$       E.  $PCl_3$

10. What is/are the main product(s) of the following reaction?



11. What is the predominant product of the following reaction?



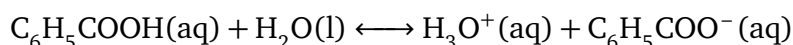
12.  $7.8 \times 10^{-5}$  mol  $Ag_2CrO_4$  can be dissolved in 1 L water at standard conditions. Calculate the solubility product of  $Ag_2CrO_4$ .

- A.  $6.0 \times 10^{-9} \frac{mol^3}{L^3}$   
 B.  $7.8 \times 10^{-5} \frac{mol^3}{L^3}$   
 C.  $2.4 \times 10^{-8} \frac{mol^3}{L^3}$   
 D.  $4.7 \times 10^{-13} \frac{mol^3}{L^3}$   
 E.  $1.9 \times 10^{-12} \frac{mol^3}{L^3}$

13. Which of the following is the strongest reducing agent?

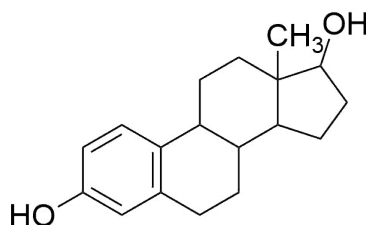
- A.  $Cl_2(g)$   
 B.  $H_2(g)$  in acidic solution  
 C.  $KI(aq)$   
 D.  $Zn(s)$   
 E.  $ZnCl_2(aq)$

14. Predict the effect on the protolysis equilibrium of benzoic acid if the water evaporates.



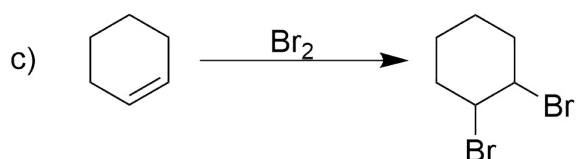
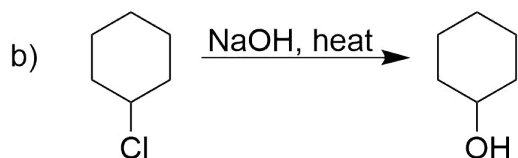
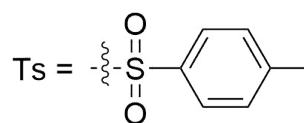
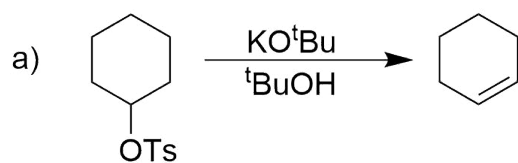
- A. shift to the right  
 B. shift to the left  
 C. increase in  $H_3O^+$   
 D. increase in  $C_6H_5COO^-$   
 E. no effect

15. How is the complex  $[\text{CoCl}(\text{NH}_3)_5]\text{Cl}_2$  named according to IUPAC?
- Dichloridopentaaminecobaltchloride
  - Tetraamminechloridocobalt(III)-dichloride
  - Pentaamminechloridocobalt(II)-trichloride
  - amminechloridocobalt-dichloride
  - Pentaamminechloridocobalt(III)-dichloride
16. The solubility product of  $\text{CaF}_2$  is  $K_L = 3.9 \times 10^{-11} \frac{\text{mol}^3}{\text{L}^3}$ . How much  $\text{CaF}_2$  can be dissolved in 1 L of water?
- $2.43 \times 10^{-1}$  mg
  - $2.10 \times 10^{-4}$  mg
  - $1.67 \times 10^1$  mg
  - $4.75 \times 10^{-1}$  mg
  - $3.34 \times 10^1$  mg
17. How many stereoisomers exist for the following compound?



- A. 22      B. 5      C. 10      D. 32      E. 16
18. A small spacecraft of capacity  $10 \text{ m}^3$  is connected to another of capacity  $30 \text{ m}^3$ . Prior to connection, the pressure inside the smaller craft is 50 kPa and that inside the larger is 100 kPa. If all measurements are made at the same temperature, what is the pressure in the combined arrangement after connection?
- A. 75.0 kPa    B. 87.5 kPa    C. 100 kPa    D. 113 kPa    E. 125 kPa
19. Chlorine can be prepared by the reaction:
- $$\text{MnO}_2(\text{s}) + 4\text{HCl}(\text{aq}) \longrightarrow \text{Cl}_2(\text{g}) + \text{MnCl}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l}).$$
- The reaction goes to completion. How many moles of HCl is used to react with 25.0 g of  $\text{MnO}_2$ ?
- A. 1.15 mol    B. 3.48 mol    C. 10.5 mol    D. 13.9 mol    E. 42.0 mol
20. Which isotope pairs share the same number of neutrons and valence shell electrons?
- $^{101}\text{Ru}^{3+}$ ,  $^{100}\text{Tc}^{2+}$
  - $^{191}\text{Os}^{1+}$ ,  $^{191}\text{Ir}^{3+}$
  - $^{19}\text{F}^-$ ,  $^{18}\text{O}^{2-}$
  - $^{31}\text{P}^{3+}$ ,  $^{30}\text{Si}^{3+}$
  - $^{72}\text{Ge}^{3+}$ ,  $^{70}\text{Zn}^{2+}$

21. Name the reaction type of the following reactions:



a)

- A. nucleophilic substitution
- B. nucleophilic addition
- C. electrophilic addition
- D. elimination
- E. rearrangement

b)

- A. nucleophilic substitution
- B. nucleophilic addition
- C. electrophilic addition
- D. elimination
- E. rearrangement

c)

- A. nucleophilic substitution
- B. nucleophilic addition
- C. electrophilic addition
- D. elimination
- E. rearrangement

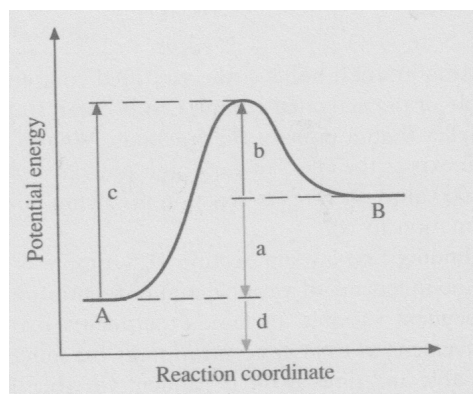
22. Ruthenium has a total of 7 stable isotopes, from  $^{96}\text{Ru}$  to  $^{104}\text{Ru}$ . The isotopes  $^{97}\text{Ru}$  and  $^{103}\text{Ru}$  both undergo radioactive decay to relief instability from a lack or excess of neutrons, respectively. Indicate the correct reaction for each isotope.

- A.  $^{97}\text{Ru} \xrightarrow{\beta^+} ^{97}\text{Tc}$
- B.  $^{97}\text{Ru} \xrightarrow{\alpha} ^{93}\text{Nb}$
- C.  $^{103}\text{Ru} \xrightarrow[\text{electron capture}]{\epsilon} ^{103}\text{Rh}$
- D.  $^{103}\text{Ru} \xrightarrow{\beta^-} ^{103}\text{Rh}$
- E.  $^{97}\text{Ru} + ^{103}\text{Ru} \xrightarrow{\text{neutron exchange}} 2 \cdot ^{100}\text{Ru}$

23. What is the energy of 1 mol photons with wavelength 500 nm?

- A. 2.5 eV      B. 241 J      C. 241 kJ      D. 241 MJ      E. 5.77 kcal

24. For the following question consider the reaction profile. For the reaction  $A \rightarrow B$ , upon adding a catalyst, which of the following statements is true?



- A. Activation energy is lower, rate is faster,  $\Delta H$  is different  
 B. Activation energy is lower, rate is slower,  $\Delta H$  is same  
 C. Activation energy is lower, rate is faster,  $\Delta H$  is same  
 D. Activation energy is higher, rate is faster,  $\Delta H$  is same  
 E. Activation energy is higher, rate is slower,  $\Delta H$  is different
25. Which of the following solutions has the lowest pH? Given are  $pK_a(\text{HCl}) = -7$ ,  $pK_a(\text{CH}_3\text{COOH}) = 4.75$ ,  $pK_a(\text{HCOOH}) = 3.75$ ,  $pK_a(\text{HBr}) = -9$
- A. HCl 0.003 M  
 B.  $\text{CH}_3\text{COOH}$  0.1 M  
 C. HBr 0.001 M  
 D. pure water  
 E. HCOOH 0.1 M
26. How many electrons are transferred from 10  $\text{I}^-$  ions to 2  $\text{MnO}_4^-$  ions in the following redox reaction?
- $$2\text{MnO}_4^-(\text{aq}) + 16\text{H}^+(\text{aq}) + 10\text{I}^-(\text{aq}) \longrightarrow 2\text{Mn}^{2+}(\text{aq}) + 5\text{I}_2(\text{s}) + 8\text{H}_2\text{O}(\text{l})$$
- A. 5      B. 7      C. 8      D. 10      E. 14
27. You have a sample of a compound containing sulfur and fluorine. The sample weighs 0.5755 g and has a volume of 255.0 mL at 288.0 K and 50.01 kPa. What is the molecular formula of this compound?
- A.  $\text{SF}_2$       B.  $\text{SF}_4$       C.  $\text{S}_2\text{F}_2$       D.  $\text{S}_4\text{F}_{10}$       E.  $\text{SF}_6$
28. How many atoms of  $^{256}\text{Lr}$  are there in a 0.0010 g sample of  $^{256}\text{Lr}$ ?
- A.  $2.35 \times 10^{18}$       B.  $4.00 \times 10^{18}$       C.  $2.05 \times 10^{19}$       D.  $11.01 \times 10^{17}$

29. The minimum voltage required to electrolyze  $\text{CuCl}_2(\text{aq})$  under standard conditions at  $25^\circ\text{C}$ ?:

- A. 1.70 V      B. 1.36 V      C. 1.02 V      D. 0.85 V      E. 0.34 V

30. A well-known physical law relates the concentration  $c$  [ $\text{mol} \cdot \text{l}^{-1}$ ], travel in solvent  $d$  [cm] and the molar extinction coefficient  $e$  to the transmittance of a solution  $T$ . Given  $d$  remains constant and the data given below, indicate a correct formula for this physical law:

$c$	0.1	1	3.14	5	10
Transmittance	0.99686	0.9686	0.9014	0.847	0.686

- A.  $T = 1 - e \cdot c \cdot d$   
B.  $T = 1 - e \cdot c^2 \cdot d$   
C.  $T = 10^{(e \cdot c \cdot d)}$   
D.  $T = 10^{(-e \cdot c \cdot d)}$   
E.  $T = 1 - 10^{(e \cdot c \cdot d)}$
31. Each answer contains two compounds which are dissolved in water in a 1:1 ratio. Which of the mixtures is/are not a buffer solution/s?
- A. HCl/KCl  
B.  $\text{CH}_3\text{COOH}/\text{CH}_3\text{COOK}$   
C.  $\text{NaNO}_3/\text{HNO}_3$   
D.  $\text{Na}_2\text{HPO}_4/\text{Na}_3\text{PO}_4$   
E.  $\text{KHCO}_3/\text{Na}_2\text{CO}_3$

### Questions without any influence on the result

32. How did you come to know about the Swiss Chemistry Olympiad?

- A. Teacher  
B. Colleagues  
C. Press  
D. Others

33. Would you take part at the Central Exam in January 2018 in case you qualify?

- A. Yes  
B. No