# HAS University of Applied science

# Chemistry - deficiency for HBM

# Trial exam exercises 2022

- For a pass, you need 10 or more (out of 18) correct answers.
- The correct answers are on the final page, including short explanations.
- The use of a calculator is allowed. Two tables are annexed:
  - o Periodic Table of the Elements, Appendix 1
  - o Redox table, Appendix 2.
- **1.** A fertilizer consists for 80% of its weight of (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>. What is the N-percentage (weight) of this fertilizer?
  - a. 8,5% (or 0,085)
  - b. 10% (or 0,10)
  - c. 17% (or 0,17)
  - d. 21% (or 0,21)
- 2. Balance the following equation:

$$CH_3COOH + O_2 \rightarrow CO_2 + H_2O$$

- a.  $CH_3COOH + O_2 \rightarrow C_2O_2 + 2 H_2O$
- b.  $CH_3COOH + O_2 \rightarrow 2 CO_2 + 2 H_2O$
- c.  $CH_3COOH + 2 O_2 \rightarrow 2 CO_2 + H_2O$
- d.  $CH_3COOH + 2 O_2 \rightarrow 2 CO_2 + 2 H_2O$
- 3. What is the number of electrons and the number of protons in a Ca<sup>2+</sup> -ion?
  - a. 18 electrons, 20 protons and 20 neutrons
  - b. 18 electrons, 20 protons and 40 neutrons
  - c. 20 electrons, 20 protons and 20 neutrons
  - d. 20 electrons, 40 protons and 20 neutrons

- **4.** What is the number of electrons and the number of protons in <sup>62</sup><sub>28</sub> Ni?
  - a. 28 electrons, 28 protons and 34 neutrons
  - b. 28 electrons, 28 protons and 62 neutrons
  - c. 28 electrons, 34 protons and 28 neutrons
  - d. 34 electrons, 28 protons and 62 neutrons
- **5.** What is the official chemical name of  $(NH_4)_2SO_4$ ?
  - a. ammonium sulphate
  - b. ammonium sulphide
  - c. diammonium sulphate
  - d. sulfuric acid
- **6.** Which of the following compounds are all soluble in water?
  - a. C<sub>2</sub>H<sub>4</sub>, H<sub>2</sub>SO<sub>4</sub>, NaOH
  - b.  $C_2H_5OH$ ,  $H_2O_2$ ,  $C_6H_6$
  - c.  $CH_4$ , KOH,  $C_{12}H_{22}O_{11}$
  - d.  $NH_3$ ,  $C_6H_{12}O_6$ ,  $CH_3COOH$
- **7.** What is the correct (balanced) equation for the formation of a precipitate of barium carbonate?
  - a. Ba (aq) + CO<sub>3</sub> (aq)  $\rightarrow$  BaCO<sub>3</sub> (s) b. Ba<sup>2+</sup> (aq) + CO<sub>3</sub><sup>-</sup> (aq)  $\rightarrow$  Ba<sub>2</sub>CO<sub>3</sub> (s)

  - c.  $Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$
  - d.  $Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow Ba^{2+}CO_3^{2-}(s)$
- 8. What is the amount of barium carbonate (mmol) that is formed if
  - 60 mL 0,23 M Ba(CH<sub>3</sub>COO)<sub>2</sub> solution is added to
  - 40 mL 0,25 M Na<sub>2</sub>CO<sub>3</sub> solution?
  - a. 3,8 mmol
  - b. 10 mmol
  - c. 14 mmol
  - d. 24 mmol
- **9.** How much mmol equals 15 g of barium carbonate?
  - a. 13 mmol
  - b. 76 mmol
  - c. 91 mmol
  - d. 197 mmol

- 10. Calculate the pH of a solution of 0,15 M HCl.
  - a. pH = 0.15
  - b. pH = 0.74
  - c. pH = 0.82
  - d. pH = 3.82
- 11. Calculate the pH of a solution of 5,00 g/L Ba(OH)<sub>2</sub>.
  - a. pH = 1,23
  - b. pH = 12,5
  - c. pH = 12.8
  - d. pH = 14,7
- **12.** What is the correct equation for the redox reaction between Au<sup>3+</sup> and Ag (see Appendix 2)?
  - a.  $Au^{3+} + Ag \rightarrow Au + Ag^{+}$
  - b.  $Au^{3+} + 3 Ag \rightarrow Au + 3 Ag^{+}$
  - c.  $Au^{3+} + 2e^{-} + Ag \rightarrow Au + Ag^{+}$
  - d. no reaction
- **13.** What is the correct equation for the redox reaction between Br<sub>2</sub> and Au (see Appendix 2)?
  - a.  $Br_2 + Au \rightarrow 2 Br + Au^{3+}$
  - b.  $Br_2 + Au \rightarrow 2 Br^2 + Au^{3+} + e^2$
  - c.  $3 Br_2 + 2 Au \rightarrow 6 Br + 2 Au^{3+}$
  - d. no reaction
- **14.** What is the correct equation for the redox reaction between  $MnO_4^-$  and  $H_2SO_3$  in acidic conditions (see Appendix 2)?
  - a.  $MnO_4^- + H_2O + H_2SO_3 \rightarrow 2 MnO_4^{2-} + SO_4^{2-} + 4 H^+$
  - b.  $MnO_4^- + H_2SO_3 \rightarrow MnO_2 + 2 H_2O$
  - c.  $2 MnO_4^- + 5 H_2SO_3 \rightarrow 2 Mn^{2+} + 5 SO_4^{2-} + 4 H^+ + 3 H_2O_4^-$
  - d. no reaction

- **15.** For the titration of 25,00 mL sulfuric acid ( $H_2SO_4$  solution) 23,86 mL 0,1005 M NaOH solution is needed. Calculate the concentration of sulfuric acid in mole per liter.
  - a. 0,01187 M
  - b. 0,04796 M
  - c. 0,09592 M
  - d. 0,1918 M
- **16.** What is the correct structural formula of 2-methylpent-2-ene?

a.

**17.** What is the correct structural formula of 3,5-diethyloctane?

# c.

# d.

# 18. What is the correct structural formula of 2-hydroxypropanoic acid?

# The correct answers are:

 $H_3C$ 

1 c. 17% (or 0,17)

2 d.  $CH_3COOH + 2 O_2 \rightarrow 2 CO_2 + 2 H_2O$ 

3 a. 18 electrons, 20 protons and 20 neutrons

4 a. 28 electrons, 28 protons and 34 neutrons

5 a. ammonium sulphate

7 c. 
$$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$$

- 8 b. 10 mmol
- 9 b. 76 mmol
- 10 c. pH = 0,82
- 11 c. pH = 12,8

12 b. 
$$Au^{3+} + 3 Ag \rightarrow Au + 3 Ag^{+}$$

13 d. no reaction

14 c. 
$$2 MnO_4^- + 5 H_2SO_3 \rightarrow 2 Mn^{2+} + 5 SO_4^{2-} + 4 H^+ + 3 H_2O_4^{2-}$$

- 15 b. 0,04796 M
- 16 a
- 17 b
- 18 a

# **Explanations**

## Question 1

% 
$$N = \frac{MW N}{MW (NH4)2SO4} \times 100\%$$

Molecular weight of (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> is (see Periodic Table of the Elements, appendix 1):

$$2 \times N = 2 \times 14,0 = 28,0$$

$$8 \times H = 8 \times 1,0 = 8,0$$

$$1 \times S = 1 \times 32, 1 = 32, 1$$

$$4 \times 0 = 4 \times 16,0 = 64,0 + 132,1 \text{ g/mol}$$

%  $N = \frac{2 \times 14.0}{132.1} \times 100\% = 21.2\%$  if 100% of the fertilizer consists of  $(NH_4)_2SO_4$ . Only 80% of the weight of the fertilizer is  $(NH_4)_2SO_4$ .

% 
$$N = \frac{21,2\%}{100} \times 80 = 16,96\%$$
 (Significance is 2) %  $N = 17\%$ 

#### Question 2

The law of conservation of mass dictates that the quantity of each element does not change in a chemical reaction. Thus, each side of the chemical equation must represent the same quantity of any particular element.

```
CH₃COOH +
                         O<sub>2</sub> →
                                 CO<sub>2</sub> +
       C: 2
                                  C: 1
       H: 4
                                  H: 2
       0: 2 + 2 = 4
                          0: 2 + 1 = 3
       First multiply CO<sub>2</sub> by 2 to gain 2 C:
       CH₃COOH +
                         O_2 \rightarrow 2 CO_2 + H_2O
       C: 2
                                  C: 2
       H: 4
                                  H: 2
       0: 2 + 2 = 4
                          0: 4 + 1 = 5
       Then multiply H<sub>2</sub>O by 2 to gain 4 H:
       CH_3COOH + O_2 \rightarrow 2 CO_2 + 2 H_2O
       C: 2
                                  C: 2
       H: 4
                                  H: 4
       0: 2 + 2 = 4
                          0: 4 + 2 = 6
       Then finally multiply O_2 by 2 to gain 6 O:
       CH_3COOH + 2 O_2 \rightarrow 2 CO_2 + 2 H_2O
       C: 2
                                  C: 2
       H: 4
                                  H: 4
0: 2 + 4 = 6
                  0: 4 + 2 = 6
```

## Question 3

20 protons (= atomic number, see Periodic Table of the Elements, appendix 1) In an uncharged atom the amount of electrons equals the amount of protons. In this case the net charge is +2, so 2 electrons are missing.

20 - 2 = 18 electrons

40 (atomic mass) - 20 (number of protons) = 20 neutrons

#### Question 4

28 protons, 62 - 28 = 34 neutrons, no net charge so 28 electrons.

#### Question 5

 $(NH_4)_2SO_4$  is a salt.

The official chemical name of a salt starts with the name of the cation (ammonium) followed by the name of the anion (sulphate): Ammonium sulphate.

# Question 6

 $NH_3$ : soluble in water because of the presence of N-H, formation of H-bonds;  $C_6H_{12}O_6$ ,  $CH_3COOH$ ,  $C_{12}H_{22}O_{11}$ ,  $C_2H_5OH$ ,  $H_2O_2$ ,  $H_2SO_4$ , NaOH: soluble in water

because of the presence of O-H, formation of H-bonds  $CH_4$ ,  $C_2H_4$ ,  $C_6H_6$ : insoluble in water because it is nonpolar.

#### Question 7

The salt barium carbonate consists of a  $Ba^{2+}$ -ion and a  $CO_3^{2-}$ -ion. The molecule barium carbonate has no net charge, so the molecular formula of barium carbonate is  $BaCO_3$  (s). The law of conservation of mass dictates that the quantity of each element does not change in a chemical reaction.

## Question 8

```
There is 60 mL x 0,23 mol/L = 13,8 mmol Ba^{2+}
There is 40 mL x 0,25 mol/L = 10 mmol CO_3^{2-}
The amount of CO_3^{2-} is limiting, so the mixture will yield 10 mmol BaCO_3 (s). (significance of 2)
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## Question 9

```
Molecular weight of BaCO<sub>3</sub> is (see Periodic Table of the Elements, appendix 1): 1 \times Ba = 1 \times 137, 3 = 137, 3 1 \times C = 1 \times 12, 0 = 12, 0 3 \times O = 3 \times 16, 0 = 48, 0 + 197, 3 \text{ g/mol}
15 \text{ g } BaCO_3 = \frac{15}{197,3} = 0,0760 \text{ mol} = 76 \text{ mmol} \text{ (significance of 2)}
```

#### Question 10

```
HCl is a strong acid: HCl (g) \rightarrow H^+(aq) + Cl^-(aq)

[H^+] = 0.15 \text{ mol/liter}

pH = -log [H^+], pH = -log (0.15) = 0.82
```

#### Question 11

```
Molecular weight of Ba(OH)<sub>2</sub> is (see Periodic Table of the Elements, appendix 1): 1 \times Ba = 1 \times 137, 3 = 137, 3 2 \times H = 2 \times 1, 0 = 2, 0 2 \times O = 2 \times 16, 0 = 32, 0 + 171, 3 \text{ g/mol}

5,00 \text{ g Ba}(OH)_2 = \frac{5,00}{171,3} = 0,0292 \text{ mol Ba}(OH)_2
Ba(OH)_2 \text{ (s) } \rightarrow Ba^{2+} \text{ (aq)} + 2 \text{ OH}^- \text{ (aq)}
0,029 \text{ mol Ba}(OH)_2 \text{ yields } 2 \times 0,0292 = 0,0584 \text{ mol OH}^-
POH = -log [OH^-], POH = -log (0,0584) = 1,23 POH = 14-POH; POH = 14-1,23 = 12,77 POH = 12,8 \text{ (significance is 3)}
```

# Question 12

 $Au^{3+}$  is a stronger oxidator than  $Ag^+$ , so a redox reaction is possible.

$$Au^{3+} + 3 e^{-} \rightarrow Au$$
 (1 x) half reaction 1  
 $Ag \longrightarrow Ag^{+} + e^{-} (3 x)$  half reaction 2  
 $Au^{3+} + 3 Ag \rightarrow Au + 3 Ag^{+}$  total redox reaction

# Question 13

 $Au^{3+}$  is a stronger oxidator than  $Br_2$ . No reaction.

## Question 14

$$MnO_4^- + 8 H^+ + 5 e^- \rightarrow Mn^{2+} + 4 H_2O$$
 (2 x) half reaction 1  
 $H_2SO_3 + H_2O$   $\rightarrow SO_4^{2-} + 4 H^+ + 2 e^-$  (5 x) half reaction 2  
 $2 MnO_4^- + 5 H_2SO_3 \rightarrow 2 Mn^{2+} + 5 SO_4^{2-} + 4 H^+ + 3 H_2O$  total redox reaction

# Question 15

23,86 mL  $\times$  0,1005 mol/L = 2,398 mmol NaOH is needed. That means also 2,398 mmol OH $^{-}$ .

This reacts with 2,398 x 0,5 = 1,199 mmol  $H_2SO_4$ . (1 mol  $H_2SO_4$  reacts with 2 mol  $H^+$ ) 1,199 mmol / 25,00 mL = 0,04796 mmol/mL = 0,04796 mol/L