

Appendix B. The questionnaires to the multimedia learning test of paper 2

Overview of the Web-based multiple-choice assessment questions for both chemistry topics

The questions are translated from Norwegian into English.

All correct answers are marked by a bracketed X.

The topic of the following 12 multiple-choice questions is alkanes and alkyn groups.

The questions 1-6 intend to measure students' retentiveness (memorized recognition of facts).

The questions 7-12 intend to measure the level of students' transfer abilities (problem-solving capacity).

Question 1-6 have five answer alternatives for each question. Only one answer alternative is correct.

1. How many types of hydrocarbons exist?

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

2. How many double bonds are there in aromatics?

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

3. What is the general formula of saturated hydrocarbons?

- a) C_2H_{2+n}
- b) C_nH_{2+n}
- c) $C_{2n}H_{n+2}$
- d) C_nH_{2n+2} (X)
- e) C_nH_{2n+3}

4. Which assertion is correct?

- a) Propane boils at a higher temperature than butane.
- b) Alkenes have triple bonds.
- c) Branching of molecules causes a lower boiling point. (X)
- d) The highest possible number of carbon atoms in alkanes is four.
- e) Alkynes have double bonds.

5. Details about the gas produced from the Troll oil rig (in Norway):

- a) The largest part of the gas is butane.
- b) Methane is flared off at the oil rig before the gas is sent to the shore.
- c) The quantities of alkanes, butane, propane, ethane and methane are the same.
- d) The major part of the gas is ethane.
- e) The major part of the gas is methane. (X)

6. Details about alkyl groups:

- a) An alkyl group has one carbon atom less than the parent alkane.
- b) An alkyl group has a vacant bond to hydrogen.
- c) An alkyl group has a vacant bond to carbon. (X)
- d) An alkyl group has two vacant bonds to carbon.
- e) An alkyl group has an equal number of carbon atoms and hydrogen atoms.

The questions 7-12 have six alternatives for each question. Three answers are correct.

7. Which assertion is correct?

- a) The freezing point increases with an increasing number of carbon atoms in the alkanes. (X)
- b) The freezing point decreases with an increased number of carbon atoms in the alkanes.
- c) The boiling point increases with branching of the carbon chain in alkanes.
- d) The boiling point decreases with a branched configuration structure of the carbon chain in alkanes. (X)
- e) The melting point increases with an increased number of carbon atoms in alkanes. (X)
- f) The melting point decreases with an increased number of carbon atoms in alkanes.

8. Questions related to a container with a mixture of methane, ethane, propane and butane gasses.

- a) Butane is a liquid and the others are gasses at room temperature.
- b) All are gasses at room temperature. (X)
- c) Methane is the first alkane which liquefies when the container is cooled down.
- d) The first alkane which liquefies when the container is cooled down is butane. (X)
- e) All alkanes will exist either as liquids or solids when the container is placed in liquid nitrogen (minus 196 degrees Celsius). (X)
- f) Many alkyl groups are formed in the mixture.

9. About differences between alkanes and alkyl groups:

- a) Alkyl groups are more reactive than alkanes. (X)
- b) Alkyl groups have higher boiling points compared with alkanes with the same number of carbon atoms.
- c) Alkyl groups have to be stored in insulated containers.
- d) Alkyl groups cannot exist as independent molecules. (X)

e) Only straight chained alkanes are able to form alkyl groups.

f) Alkyl groups exist in all types of organic molecules. (X)

10. Regarding cooking devices

a) All alkanes are combustible. (X)

b) Only alkanes which are gasses by room temperatures are combustibles.

c) Propane devices are bad functioning when they are placed into snow.

d) Propane devices are of the same type as butane devices?

e) Alkanes with five carbon atoms are not suited for boiling devices. (X)

f) Propane cooking appliances are more vulnerable for leakages than butane cooking devices. (X)

11. Regarding straight chained and branched alkanes

a) Branched alkanes have a higher number of hydrogen atoms than straight chained alkanes even with the same number of carbon atoms.

b) Straight chained alkanes have the same structural formula as branched alkanes with the same number of hydrogen atoms.

c) Branched alkanes have the same molecular formula as straight chained with the same number of hydrogen atoms. (X)

d) Straight chained alkanes have a higher boiling point compared with branched. (X)

e) Side groups only consist of methyl groups.

f) Side groups only consist of alkyl groups with a variable number of carbon atoms. (X)

12 Regarding the fact that the number of carbon atoms in an alkane increases:

a) The number of branched molecules will always be constant.

b) The number of branched molecules rises consecutively with the number of carbon atoms.

c) The number of branched molecules rises exponentially with the number of carbon atoms. (X)

- d) Alkanes with many carbon atoms are solid compounds at room temperatures. (X)
- e) The boiling point goes up in a linear manner with an increased number of carbon atoms.
- f) The boiling point goes down with an increased number of carbon atoms. (X)

The topic of the following 12 multiple-choice questions is the range of electrode potentials.

The questions 1-6 intend to measure students' retentiveness (memorized recognition of facts).

The questions 7-12 intend to measure the level of students' transfer abilities (problem-solving capacity).

Questions 1-6 have five answer alternatives for each question. Only one answer alternative is correct.

1. Which metal has the strongest attraction on its electrons?

- a) Lead.
- b) Iron.
- c) Copper.
- d) Zinc. ?
- e) Silver. (X)

2. Which metal will coat the substance when it is dropped into a lead nitrate solution?

- a) Lead.
- b) Gold.
- c) Copper.
- d) Zinc. (X)
- e) Silver.

3. From which metal does a zinc ion pull electrons?

- a) Lead.
- b) Copper.
- c) Zinc.
- d) Silver.
- e) None of them. (X)

4. What happens if you lose a silver jewellery into a copper sulphate solution?

- a) Copper will be attached to the jewellery.
- b) Silver ions will dissolve into the solution.
- c) The jewellery will crumble.
- d) Nothing. (X)
- e) Copper metal evolves on the bottom of the beaker.

5. Electrons are able to migrate:

- a) From one metal to another which has a higher electrode potential.
- b) From one metal to another which has a lower electrode potential.
- c) From a metal ion to a metal which has a higher electrode potential.
- d) From a metal ion to a metal which has a lower electrode potential.
- e) From a metal to a metal ion which has a higher electrode potential. (X)

6. When zinc metal is dropped into a solution with copper sulphate the blue colour gradually disappears. Why?

- a) Sulphate ions are binding to the zinc metal.
- b) Sulphate ions precipitate.
- c) A zinc sulphate solution is colorless. (X)
- d) Copper sulphate settles on the zinc metal.
- e) Sulphate has a higher electrode potential than zinc.

The questions 7-12 have six answer alternatives for each question. Three answers alternatives are correct.

7. At the bottom section of an iron oil rig there are fastened blocks of Zinc. Why?

- a) To make them more robust.
- b) To prevent rust. (X)
- c) Because zinc has a higher electrode potential than iron.
- d) Because zinc has a lower electrode potential than iron. (X)
- e) Because zinc delivers electrons to iron ions. (X)
- f) Because iron delivers electrons to zinc ions.

8. A roof of copper is fastened with iron nails. What happens?

- a) The roof becomes strong and solid.
- b) The roof gradually starts to leak. (X)
- c) The iron nails erodes. (X)
- d) The copper plates erode.
- e) Copper ions are created.
- f) Iron ions are created. (X)

9. A galvanic cell consists of a zinc rod in a beaker with water and a copper rod in a copper solution in another beaker. Between the two beakers there is a salt bridge and a cord is connected to the two metal sticks with a electric bulb. What will happen?

- a) The bulb will shine. (X)
- b) The bulb will not shine.
- c) Copper ions dissolve from the copper rod.
- d) Copper metal will settle on the copper rod. (X)
- e) Zinc ions dissolve from the zinc rod. (X)
- f) Zinc metal will settle on the zinc rod.

10. The bumper of a car is made of iron which is galvanized with nickel to protect it against rust (and because of its beauty). If a leak should emerge on the galvanized surface the bumper would rust faster at the leakage than elsewhere. Why?

- a) Nickel has a higher electrode potential than iron. (X)

- b) Nickel has a lower electrode potential than iron.
- c) Nickel pulls electrons out of iron. (X)
- d) Iron pulls electrons out of nickel.
- e) Iron metal settles on the nickel.
- f) Iron ions will be created in water on the bumper. (X)

11. What will happen when we try to extract aluminium through electrolysis of a solution of aluminium ions?

- a) The aluminium metal settles on the cathode.
- b) Hydrogen gas rises from the cathode. (X)
- c) Hydrogen has a lower electrode potential than aluminium.
- d) Hydrogen has a higher electrode potential than aluminium. (X)
- e) Electrons are delivered from the cathode to aluminium ions.
- f) Electrons are delivered from the cathode to water molecules.

12. A rod of copper is placed into a beaker with a silver nitrate solution. Which of the following equations are correct?

- 1. $\text{Cu} = \text{Cu}^{2+} + 2\text{e}^-$, (X)
- 2. $\text{Cu}^{2+} + \text{Ag} = \text{Cu} + \text{Ag}^{2+}$
- 3. $2\text{Ag}^+ + \text{e}^- = 2\text{Ag}$
- 4. $2\text{Ag}^+ + \text{Cu} = 2\text{Ag} + \text{Cu}^{2+}$, (X)
- 5. $\text{Ag}^{2+} + 2\text{e}^- = \text{Ag}$
- 6. $\text{Ag}^+ + \text{e}^- = \text{Ag}$, (X)