UNIVERSITY OF AMSTERDAM

Chemistry example test questions

Time: 180 minutes

This test consists of four main questions Main

question	Maximum Points
1	40
2	30
3	15
4	15

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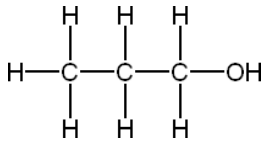
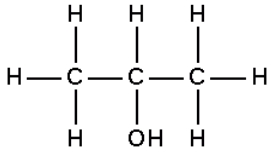
1 Twenty multiple choice questions (2 points for each correct answer)

1) After complete oxidation of compounds I and II, the final type of functional groups are

	I	II
(a)	carboxylic acid	ketone
(b)	aldehyde	ketone
(c)	carboxylic acid	carboxylic acid
(d)	ketone	aldehyde



I



II

2) The formula of an ionic material that contains only the elements magnesium and phosphorus would most likely be

(a) MgP
(b) Mg_2P_3
(c) Mg_3P_2
(d) Mg_4P_3

3) The compound $CaCO_3$ (chalk) contains

(a) No ionic bonds
(b) No covalent bonds
(c) Both ionic and covalent bonds
(d) Only ionic bonds

4) Which of the four particles is not a radical

(a) NO
(b) NO_2
(c) ClO_2
(d) ClO_2^-

5) The amount of equivalent resonance structures that is needed to describe the Lewis structure of $HClO_4$ equals

(a) One
(b) Two
(c) Three
(d) Four

6) The isotope $^{79}Se^{2-}$ contains
   (a) 45 protons, 34 neutrons and 32 electrons
   (b) 45 protons, 34 neutrons and 36 electrons
   (c) 34 protons, 45 neutrons and 36 electrons
   (d) 34 protons, 45 neutrons and 32 electrons

7) The bond between the two carbon atoms in the particle C_2H_2 consists of
   (a) 1 σ bond
   (b) 1σ bond and 1 π bond
   (c) 1σ bond and 2 π bonds
   (d) 1σ bond and 3 π bonds

8) Which compound has the highest ionic bond character
   (a) LiF
   (b) KF
   (c) NaBr
   (d) LiBr

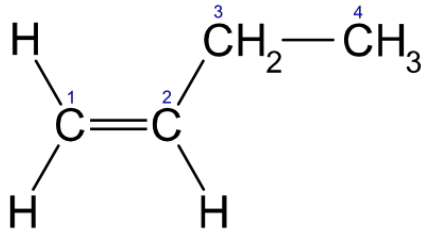
9) The type of copper cations in the blue-colored pigment azurite $Cu_3(CO_3)_2(OH)_2$ are:
   (a) both Cu^+ and Cu^{2+}, but more Cu^+
   (b) both Cu^+ and Cu^{2+}, but more Cu^{2+}
   (c) only Cu^+
   (d) only Cu^{2+}

10) One of the following molecules is non-polar (apolar), which one:
   (a) O_3
   (b) SO_3
   (c) NH_3
   (d) CH_2Cl_2

11) The amount of valence electrons of the ion Co^{3+} equals
   (a) 6
   (b) 7
   (c) 8
   (d) 9

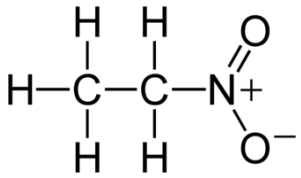
12) The intermolecular interactions present in liquid ammonia (NH_3) consist of:
   (a) London (dispersion) forces
   (b) London (dispersion) forces and dipole-dipole interactions
   (c) Dipole-dipole interactions and hydrogen bonds
   (d) London (dispersion) forces, dipole-dipole interactions and hydrogen bonds

13) The molecular shape at the carbon atoms numbered (in blue) 1 and 3 as shown below is as follows



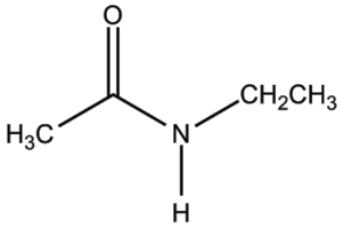
	1	3
(a)	tetrahedral	tetrahedral
(b)	tetrahedral	trigonal planar
(c)	trigonal planar	tetrahedral
(d)	trigonal planar	trigonal planar

14) The amount of lone pairs needed to complete the Lewis structure of the compound shown below equals



(a) 3
(b) 4
(c) 5
(d) 6

15) If the compound shown below is hydrolyzed, the products are



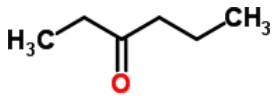
(a) a carboxylic acid and an amine
(b) an alcohol and an ether
(c) a carboxylic acid and an amide
(d) an amine and a ketone

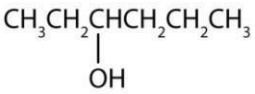
16) Which of the following statements is correct? If a base is added to a solution then
(a) the $[OH^-]$ decreases
(b) the $[H_3O^+]$ increases
(c) the pH increases
(d) the pH decreases

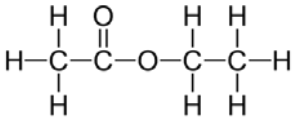
17) If two solutions are made, solution I by dissolving some NH_4Cl in waterand solution II by dissolving some NaCl in water, it can be statedthat:
(a) Solution I is acidic and solution II is neutral
(b) Solution I is neutral and solution II is acidic
(c) Both solutions I and II are neutral
(d) Both solutions I and II are acidic

18) The pOH of a 0.0015 M HCl solution is in the interval
(a) 2-3
(b) 3-4
(c) 11-12
(d) 12-13

19) Which functional group is not present in either of the compounds I, II and III





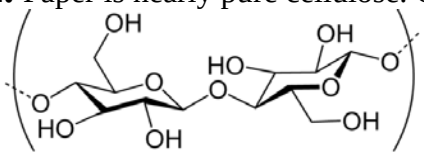


I II III

(a) An alcohol
(b) A carboxylic acid
(c) An ester
(d) A ketone

20) Rank the following four bases from left to right according to increasing basicity (= alkalinity)
Aniline ($pK_b = 9.37$), hydrazine ($pK_b = 5.77$) , methylamine ($K_b = 3.6x10^{-4}$) ammonia ($K_b = 1.8x10^{-5}$)
(a) aniline, hydrazine, ammonia, methylamine
(b) hydrazine, aniline, ammonia, methylamine
(c) methylamine, ammonia, hydrazine, aniline
(d) aniline, hydrazine,methylamine, ammonia

2. Paper is nearly pure cellulose. Cellulose consists of long chains of glucose units



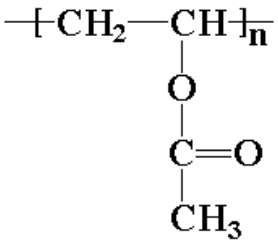
Cellulose. The 'n' denotes repetition of the glucose unit

a) (3points) Which functional group(s) are present in cellulose.

The use of oxidizing agents (e.g. bleaches) on paper in combination with water (humid conditions) can result in acidic conditions in paper.

b) (6 points) Explain why these acidic conditions can occur.

Also wood consists for a large part of cellulose. Polyvinyl acetate (= PVA or PVAc) is frequently used as an adhesive for wood.



Polyvinyl acetate. The 'n' denotes repetition of the vinyl acetate unit

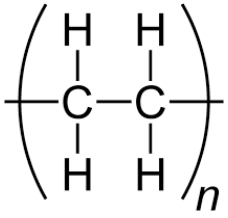
c) (3 points) Which type of functional group is present in polyvinyl acetate.

d) (6 points) Explain on which principle the binding between polyvinyl acetate and cellulose is expected to be based.

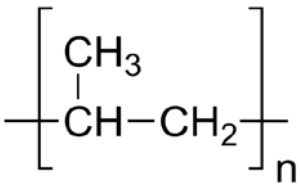
PVAc should not be used as adhesive on wood if the humidity level is continuously high.

e) (6 points) Explain what may happen under these conditions.

f) (6 points) Give an explanation for the observation that PVAc works less well as adhesive on polymers like polyethylene and polypropylene.

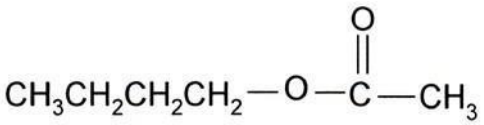


Polyethylene
The 'n' denotes repetition of the ethylene unit

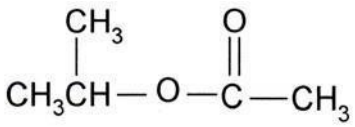


Polypropylene
The 'n' denotes repetition of the propylene unit

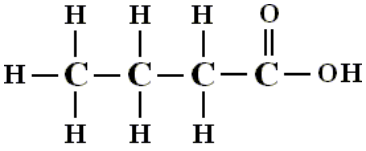
3. a) (8 points) Order the four compounds butyl acetate, isopropyl acetate, hexane and butanoic acid according to increasing boiling point and give an explanation for this order.



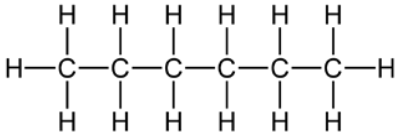
Butyl acetate



Isopropyl acetate



butanoic acid (butyric acid)

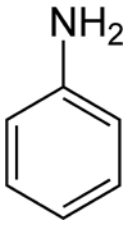


Hexane

b) (7 points) Explain which of the compounds isopropyl acetate, butyl acetate, butanoic acid and hexane will mix the best with water, and which one the worst.

4. Below the basicity constants of the weak bases aniline and ammonia (NH_3) are listed

base	K_b
Aniline	4.3×10^{-10}
Ammonia	1.8×10^{-5}



Aniline

a) (5 points) Explain whether ammonia (NH_3) is less basic or more basic than aniline and give an explanation for this difference in basicity.

b) (5 points) Explain whether the compound NH_2Cl is expected to be more basic or less basic than NH_3.

c) (5 points) Calculate the pK_a value of NH_4^+, the conjugated acid ofammonia.

On the next pages you will find the answers…

Answers Chemistry practice test

1 1A 2C 3C 4D 5A 6C 7C 8B 9D 10B 11A 12D 13C 14C 15A 16C 17A 18C 19B 20C

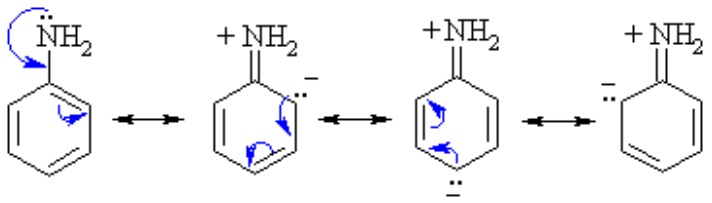
2 a) (primary and secondary) alcohols and ethers
Hemiacetal is also correct
b) Primary alcohols can be oxidized to aldehydes, and aldehydes to carboxylic acids. The latter behave as weak acids in water
c) Ester
d) Dipole-dipole interactions and hydrogen bonds between the OH groups in cellulose and the esters in PVAc
e) The esters are hydrolyzed into alcohols and acetic acid. The latter is a carboxylic acid, so (in water) a weak acid (see question 2b) and the released acidic H_3O^+ can disturb the hydrogen bonds (see question 2d) so the adhesion decreases.
f) No dipole-dipole interactions and hydrogen bonds possible between the OH groups in cellulose and both polyethylene and polypropylene, only London (dispersion) forces so the adhesion will be worse compared to PVAc

3 a) LF = London (dispersion) forces, DP = Dipole-dipole interactions, HB = hydrogen bonds

The order is : hexane, isopropyl acetate, butyl acetate, butanoic acid
Hexane only has LF so the lowest boiling point.
Butanoic acid has the highest boiling point. In addition to the LF and DP (approximately similar to those in isopropyl acetate and butyl acetate), butanoic acid forms HB, and these HB are extra strong (dimers).
Butyl acetate has a higher boiling point than isopropyl acetate. The LF in butyl acetate are stronger than in isopropyl acetate. Butyl acetate has more (eight) non-H atoms than isopropyl acetate (seven non-H) and the left-hand side of butyl acetate has a less spherical shape (so a larger contact area, thus stronger LF) than isopropyl acetate.

b) Compounds that have similar intermolecular interactions mix the best. Water has (small) LF, DP and HB. Hexane lacks DP and HB so will mix the worst, butanoic acid has LF, DP and HB, so is expected to mix the best with water

4 a) The K_b value of ammonia is larger than the K_b of aniline so ammonia is the stronger base. In ammonia the lone pair is localized at the N, so completely available to bind a H^+. In aniline, however, the lone pair is delocalized, so it less available to bind a H^+.



b) NH_2Cl is less basic than NH_3 because the electronegative chlorine pulls electrons away from the nitrogen, so making the lone pair at the nitrogen less available to bind a H^+.

c) The $pK_b(NH_3) = -\log(K_b(NH_3)) = 5-\log(1.8) = 4.74$
Because $pK_b(NH_3) + pK_a(NH_4^+) = 14$, the $pK_a(NH_4^+) = 14-4.74 = 9.26$