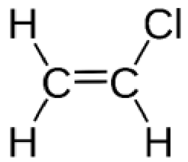
Polymer Science Part

Polymer science

1. Polyvinylchloride is made by polymerizing the monomer vinyl chloride.



   (a) How is the process to start this polymerization called?
   (b) Which class of polymerizations does this polymerization fall into?
   (c) Draw the molecular structure of polyvinyl chloride.

2. The mechanical properties of polymers are directly related to their thermal transitions.

   (a) Explain what the Elastic modulus of a polymer is.
   (b) Draw the Elastic modulus of a semi-crystalline polymer as a function of the temperature.

3. You are going to buy new glasses. Is it more likely that your glasses are made from a semi-crystalline polymer or an amorphous polymer? Explain why.

Biomolecules Part

1. How many members does a pyranose ring contain?
A. 4
B. 5
C. 6
D. 7

2. How many carbons are present in an isoprene?
A. 10
B. 5
C. 15
D. 12

3. Most natural amino acids have the …. configuration.
A. D
B. L
C. Alpha
D. Beta

4. Maltose (α-D-glucopyranosyl-(1->4)-α-D-glucopyranoside) is a …… sugar.
A. Reducing
B. Neutral
C. Non-reducing
D. Complex

5. How many hydrogen bonds are there between adenine and thymine?
   A. 1
   B. 2
   C. 3
   D. none

Name: Student nr.

Open questions (**1A, 1B**).

1. Please draw the Fisher structure of
   A. the D-isomer of a C6 keto sugar (20 points)

   B. the C4 epimer of the same sugar (10 points)

Chemistry Part

1. Oil refineries produce a fraction that consists of a mixture of butenes shown below together with their boiling points (bp), melting points (mp), water solubility (W_{sol}) and density as a liquid (d_{liquid}).

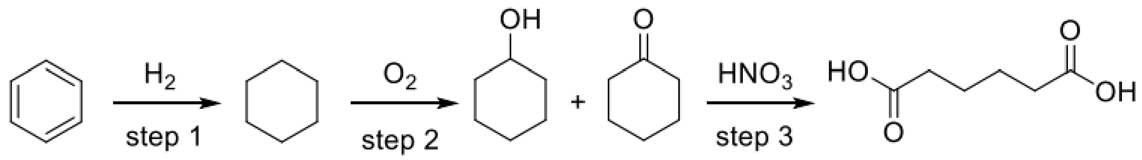
	A	B	C	D
bp	266.9 K	274.0 K	286.9 K	266.3 K
mp	87.8 K	167.7 K	134.3 K	132.9 K
W_{sol}	insoluble	insoluble	insoluble	insoluble
d_{liquid}	0.62 g/cm^3	0.63 g/cm^3	0.64 g/cm^3	0.59 g/cm^3

   a. Name all four components **A-D** of this mixture
   b. Indicate what type of isomers components **A**-**D** are.

The butenes are commonly dimerized to produce plasticizers. An example reaction is shown below. For this reaction the whole mixtures is used to obtain a new mixture that is use for further reactions

During the dimerization reaction, the location of the double bond is also varied by an ongoing secondary isomerization reaction.

   e. Provide an additional 10 products (draw the structures) and name them (do not worry about selectivity or stability of the products just make sure the product can be formed by dimerization followed by isomerization).

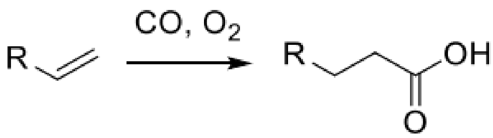


A B C D E

a. Match the following name with the right compound **A**-**E**: cyclohexanol, hexanedioic acid, cyclohexane, benzene, cyclohexanone.

c. Assuming that step 2 gives a 1 : 1 mixture of **C** and **D** and water is released as a side product, rewrite the reaction equation and balance it. What will change in the equation when the reaction is selective for **C**?

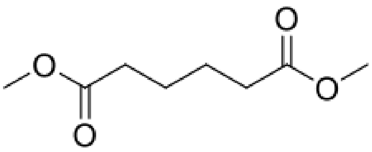
d. Step 1 and 2 do not happen spontaneously and simply heating the reaction till a reaction takes place will lead to many side reactions. What is required to have these reaction happen selectively to the desired product.



i. Balance the reaction equation for R = H (ethylene) and provide atom economy.

j. Provide the E-factor for R = H (ethylene) given that for every 1000 Kg of product 50 Kg of side products are generated. Is that suitable for industrial implementation of the process for this bulk chemical?

f. Use the Lewis structure of compound **E** and the type of interactions this allows to explain why this compound is water soluble and the compound shown below is not.



g. To form Nylon from acidic compound **E** an acid additive is required that is a stronger acid. Provide the name and chemical formula of such an acid that is largely available and cheap.

Material Science Part

Exercise 1: Mechanical properties of materials (8 pt)

a. A brass (Cu-Zn alloy) bar, with a diameter of 20 mm, is loaded parallel along its long axis. The diameter of the bar changes 5 μm as a consequence of the loading. Compute the value of the load (in kilograms) that has been put on the bar. Assume that the bar is loaded completely elastic. However, check after the calculation whether this assumption was justified. The yield strength of the brass is 75 MPa, its Young's modulus 97 GPa, its Poisson's ratio 0.34. (4 pt)

b. Describe 2 methods by which a metal (material) can be strengthened. Explain concisely why strengthening occurs. A certain type of defects plays a crucial role. What is the name of these defects; describe their role. (4 pt)

Exercise 2: Electrical properties of materials (10 pt)

Pure copper has at 20 ^{0}C a conductivity of 6.0 10^7 $(\Omega m)^{-1}$. Pure silver has 6.8 10^7 $(\Omega m)^{-1}$.

a. Approximately determine the value for the conductivity of Cu at 170 ^{0}C. Explain why the change in conductivity occurs with temperature change. (3 pt)

b. The Cu is alloyed with 2 at.% Ag. Does the conductivity of the alloy becomes worse or better than the one of pure Cu? Explain your answer. (2 pt)

c. Intrinsic GaAs has at room temperature a conductivity of 10^{-6} $(\Omega m)^{-1}$. The mobility of the electrons and the holes is 0.88 and 0.04 $m^2/(Vs)$, respectively. The unit charge e = 0.16 10^{-18} C, Avogadro's number N_{Av} = 6 10^{23} $(mole)^{-1}$ and Boltzmann's constant k = 8.617 10^{-5} eV/K. What is the number of conduction electrons and what is the number of holes at room temperature? (3 pt)

d. Does the conductivity of an intrinsic semiconductor increase or decrease when the temperature is increased? Motivate your answer. (2 pt)

Exercise 3: Materials selection and design (8 pt)

In the figure below a so-called 'Ashby map' is shown, in which the stiffness (Young's modulus E) is plotted versus the density (ρ) for a large number of materials (classes). We want to design an axis of a turbine with a minimum weight. When the axis is loaded in torsion and the design has to be sufficiently stiff, materials with the highest possible value for $E^{0.5}/\rho$ are most suitable. When the axis is loaded in tension, materials with the highest possible value for E/ρ are most suitable. We can choose between aluminum alloys, titanium alloys and steel.

a. How do the performances of the 3 materials compare for torsional loading? Motivate your answer. (2 pt)

b. How do the performances of the 3 materials compare for tensile loading? Motivate your answer. (2 pt)

c. The shape factor for bending is defined as $\phi_B^e = 4\pi I_{xx}/A^2$ with $I_{xx} = \int y^2 dA$ with y the distance to the bending axis and A the cross-sectional area. We have two rectangular cross-sections with the same area as shown on the right, where in both cases the bending axis is oriented horizontal as indicated by the dashed line. Calculate (in terms of dimensions c and d) for both shapes first the second moment of area I_{xx} (in principle you can do this with one calculation) and then the shape factors. Which one of the two has a larger shape factor and is thus more efficient? (4 pt)