Problem 1a

i. Barium chloride (Bariumklorid)

ii. Cobalt(III) phosphate (Kobalt(III)fosfat)

iii. Cobalt(II) phosphate (Kobalt(II)fosfat)

iv. Cesium hydroxide (Cesiumhydroksid)

Problem 1b

i. **Step 1.** Balance the H-atoms:

$Sr(OH)_2 + 2HCl \rightarrow SrCl_2 + 2H_2O$

Step 2. Count the atoms in the reaction equation to make sure that each side has the same number of atoms of each element:

	$Sr(OH)_2 + 2HCl \rightarrow SrCl_2 + 2H_2O$
Sr:	Left-hand side = Right-hand side = 1, ok
O:	Left-hand side = Right-hand side = 2, ok
H:	Left-hand side = Right-hand side = 4, ok
Cl:	Left-hand side = Right-hand side = 2, ok

ii. **Step 1.** Balance the H-atoms:

$C_{12}H_{22}O_{11} + O_2 \rightarrow CO_2 + 11H_2O$

Step 2. Balance the C-atoms:

$C_{12}H_{22}O_{11} + O_2 \rightarrow 12CO_2 + 11H_2O$

Step 3. Balance the O-atoms:

$C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$

Step 2. Count the atoms in the reaction equation to make sure that each side has the same number of atoms of each element:

	$C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$
C:	Left-hand side = Right-hand side = 12, ok
O:	Left-hand side = Right-hand side = 35, ok
H:	Left-hand side = Right-hand side = 22, ok

iii. **Step 1.** Balance the H-atoms:

$C_4H_6 + 2H_2O \rightarrow C_4H_{10}O_2$

Step 2. Count the atoms in the reaction equation to make sure that each side has the same number of atoms of each element:

	$C_4H_6 + 2H_2O \rightarrow C_4H_{10}O_2$
C:	Left-hand side = Right-hand side = 4, ok
O:	Left-hand side = Right-hand side = 2, ok
H:	Left-hand side = Right-hand side = 10, ok

iv. **Step 1.** Balance the charge:

$3Hg_2^{2+} + Al \rightarrow Hg + 2Al^{3+}$

Step 2. Balance the Al-atoms:

$3Hg_2^{2+} + 2Al \rightarrow Hg + 2Al^{3+}$

Step 3. Balance the Hg-atoms:

$3Hg_2^{2+} + 2Al \rightarrow 6Hg + 2Al^{3+}$

Step 4. Count the atoms and charges in the reaction equation to make sure that each side has the same number of atoms of each element and the same charge:

	$3Hg_2^{2+} + 2Al \rightarrow 6Hg + 2Al^{3+}$
Hg:	Left-hand side = Right-hand side = 6, ok
Al:	Left-hand side = Right-hand side = 2, ok
Charge:	Left-hand side = Right-hand side = +6, ok

Problem 1c

i. ON: $\overset{?}{Co_2}\overset{-2}{O_3}$ $2(?) + 3(-2) = 0$ gives ? =+ 3

Co: +3
O: -2

ii. ON: $\overset{?}{C_2}\overset{+1}{H_3}\overset{-2}{O_2^-}$ $2(?) + 3(+1) + 2(-2) = -1$ gives ? = 0

C: 0
H: +1
O: -2

iii. ON: $\overset{+1}{H}\overset{?}{S}\overset{-2}{O_4^-}$ $(+1) + (?) + 4(-2) = -1$ gives ? = +6

S: +6
H: +1
O: -2

iv. ON: $\overset{?}{Sn}\overset{-1}{H_4}$ $(?) + 4(-1) = 0$ gives ? = +4

Sn: +4
H: -1

Problem 1d

	$2C_2H_2(g)$	+ $5O_2(g)$ →	$4CO_2(g)$	+ $2H_2O(g)$
I (m):	2.00 g		0	-
I(n):	$n = \frac{m}{M} = \frac{2.00\ g}{26.04 g/mol} = 0.0768\ mol$	-	0	-
AR (n):	0	-	$n = \frac{4}{2} \times 0.0768\ mol = 0.154 mol$	-
AR (m):	0	-	$m = nM = (0.154 mol)(44.01 g/mol) = 6.76 g$	-

BR = before reaction, AR = after reaction

Problem 2a

$HCl(g)$	+	$NH_3(g)$	→	$Cl^-(g)$	+	$NH_4^+(g)$
Acid		Base		Conjugated base		Conjugated acid

Problem 2b

HCl reacts as an Brønsted acid because it gives away a proton, H^+, to NH_3, but not as an Arrhenius acid because it does not increase the concentration of hydronium ions, H_3O^+, in water.

Problem 2c

Step 1.

Calculate 2.50 g $Ba(OH)_2$ into number of moles $Ba(OH)_2$:

$$n = \frac{m}{M} = \frac{2.50g}{171.34g/mol} = 0.01459 \text{ mol}$$

Step 2. Calculate the molar concentration of a 1.00 $Ba(OH)_2(aq)$ solution, which contains 0.01459 mol of 1.00 $Ba(OH)_2$:

$$c = \frac{n}{V} = \frac{0.01459 \text{ mol}}{1.00 \text{ L}} = 0.01459 \text{ M}$$

Step 3. Create a "before reaction (BR) – after reaction (AR) table" and include the molar concentration before and after reaction:

	$Ba(OH)_2(aq)$	→	$Ba^{2+}(aq)$	+	$2OH^{-}(aq)$
BR(*c*):	0.01459 M		0		0
AR(*c*):	0		0.01459 M		0.02918 M

Step 4. Calculate the pOH of the solution:

$$pOH = -\log[OH^{-}] = -\log(0.02918) = 1.53$$

Step 5. Use the expression:

pH + pOH = 14.00

to calculate the pH of the solution:

pH + 1.53 = 14.00 gives pH = 12.47

Problem 2d

Step 1. Use the pH-formula:

$$pH = -\log[H_3O^{+}]$$

to calculate the molar concentration of H_3O^+ ions in a $C_6H_5CO_2H(aq)$ solution of pH = 3.00 from the formula:

$$3.00 = -\log[H_3O^{+}] \text{ gives } [H_3O^{+}] = 10^{-3.00}\text{M}$$

Step 2. Create an ICE-table for the dissociation of $C_6H_5CO_2H$ and include the molar concentrations of each species (the H_3O^+ and $C_6H_5CO_2^-$ ions have the same source, namely, $C_6H_5CO_2H$):

	$C_6H_5CO_2H(aq)$	+	$H_2O(l)$	$\rightleftharpoons$	$C_6H_5CO_2^-(aq)$	+	$H_3O^+(aq)$
Initial:	*c* M		-		0		0
Change:	$-10^{-3.00}$ M				$+10^{-3.00}$ M		$+10^{-3.00}$ M
Equilibrium:	(c - $10^{-3.00}$) M				$10^{-3.00}$ M		$10^{-3.00}$ M

Step 3. Insert the equilibrium molar concentrations into the expression of the acid constant, Ka, for $C_6H_5CO_2H$:

$$K_a = \frac{[C_6H_5CO_2^-][H_3O^+]}{[C_6H_5CO_2H]} = 6.3 \times 10^{-5}$$

to calculate the initial molar concentration, c, of $C_6H_5CO_2H$ in the $C_6H_5CO_2H(aq)$ solution:

$$\frac{(10^{-3.00}) \times (10^{-3.00})}{(c - 10^{-3.00})} = 6.3 \times 10^{-5} \text{gives } c = 0.01687 \text{ M}$$

Step 4. Use the molarity formula:

$$c = \frac{n}{V}$$

to calculate the initial number of moles of $C_6H_5CO_2H$:

$$0.01687 \frac{mol}{L} = \frac{n}{10.0L} \text{ gives } n = 0.1687 \text{ mol}$$

Step 4. Calculate the mass $C_6H_5CO_2H$ required to prepare 10.0 L of a $C_6H_5CO_2H(aq)$ solution of pH = 3.00:

$$m = nM = (0.1687mol) \times (122.3g/mol) = 20.6 \text{ g } C_6H_5CO_2H$$

Problem 3a

Step 1. Insert real values into the density formula:

$$d = \frac{m_{solution}}{V_{solution}}$$

to calculate the mass for 1.00 L (1000 mL) of 20.0 mass% $CH_3CH_2OH(aq)$ solution:

$$0.972g/mL = \frac{m_{solution}}{1000 \text{ L}} \text{ gives } m_{solution} = 972 \text{ g}$$

Step 2. Insert real values into the formula:

$$\text{Mass\% solute} = \frac{m_{solute}}{m_{solution}} \times 100\%$$

to calculate the mass CH_3CH_2OH in 1.00 L (972 g) of 20.0 mass% $CH_3CH_2OH(aq)$ solution:

$$20.0\% = \frac{m_{solute}}{972\ g} \times 100\% \text{ gives } m_{solute} = 194.4\ g$$

Step 3. Convert 194.4 g of CH_3CH_2OH into number of moles:

$$n = \frac{m}{M} = \frac{194.4g}{46.07g/mol} = 4.22\ mol$$

Problem 3b

Step 1. Because the density of an 85-mass% HCO_2H (aq) solution is 1.22 g/mL, it follows that 1.00 mL (1.00×10^{-3} L) (= $V_{solution}$) solution has the mass of 1.22 g (= $m_{solution}$).

Step 2. Insert real values into the formula:

$$\text{Mass\% solute} = \frac{m_{solute}}{m_{solution}} \times 100\% = \frac{n_{solute} \times M_{solute}}{m_{solution}} \times 100\% = \frac{(c_{conc} \times V_{solution}) \times M_{solute}}{m_{solution}} \times 100\%$$

to calculate the molar concentration, c_{conc}, of a 85-mass% HCO_2H (aq) solution:

$$85.0\% = \frac{c_{conc} \times (1.00 \times 10^{-3} L) \times 46.03g/mol}{1.22\ g} \times 100\% \text{ gives } c_{conc} = 22.5\ M$$

Step 3. Insert real values into the dilution formula:

$$c_{conc} \times V_{conc} = c_{dil} \times V_{dil}$$

to calculate the volume, V_{conc}, required of an 85%-mass% (22.5 = c_{conc}) $HCO_2H(aq)$ solution to prepare 4.00 L (= V_{dil}) of a 3.00 M (= c_{dil}) $HCO_2H(aq)$ solution:

$$(22.5\ M) \times V_{conc} = 3.00\ M \times (4.00\ L) \text{ gives } V_{conc} = 0.53\ L$$

That is, 0.530 L of 85-mass% $HCO_2H(aq)$ solution and of 3.47 L water is required to prepare 4.00 L of a 3.00 M $HCO_2H(aq)$ solution.

Problem 3c

Step 1. Rearrange the equation of the ideal gas law:

$$PV = nRT \Leftrightarrow \frac{n}{V} = \frac{P}{RT}$$

to calculate the molar concentrations for NO_2 and N_2O_4 at chemical equilibrium:

$$[NO_2] = \frac{n}{V} = \frac{P}{RT} = \frac{1.00\text{ atm}}{(0.08206\text{L} \times \text{atm/K} \times \text{mol}) \times (353.15\text{K})} = 0.034507\text{ M}$$

$$[N_2O_4] = \frac{n}{V} = \frac{P}{RT} = \frac{5.30\text{ atm}}{(0.08206\text{L} \times \text{atm/K} \times \text{mol}) \times (353.15\text{K})} = 0.18289\text{ M}$$

Step 1. Calculate the equilibrium constant:

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} = \frac{0.18289}{(0.034507)^2} = 153$$

Problem 3d

Step 1. Rearrange the equation of the ideal gas law:

$$PV = nRT \Leftrightarrow \frac{n}{V} = \frac{P}{RT}$$

to calculate the initial molar concentrations of NO_2:

$$c_{NO_2} = \frac{n}{V} = \frac{P}{RT} = \frac{10.0\text{ atm}}{(0.08206\text{L} \times \text{atm/K} \times \text{mol}) \times (353.15\text{K})} = 0.34507\text{ M}$$

Step 2. Create an ICE-table and include the molar concentrations for each species:

	$2NO_2(g)$	$\rightleftharpoons$	$N_2O_4(g)$
Initial:	0.34507 M		0.18289 M
Change:	-2x M		+x M
Equilibrium:	(0.34507 -2x) M		(0.18289 + x) M

Step 3. Insert the equilibrium molar concentrations into the expression for the equilibrium constant, K_c:

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} = 153$$

to find x:

$$K_c = \frac{0.18289 + x}{(0.34507 - 2x)^2} = 153 \text{ gives } x = 0.155227\ \mathrm{M}$$

Step 4. Calculate the mol concentrations for NO_2 and N_2O_4 at chemical equilibrium:

$$[NO_2] = (0.34507 - 2 \times 0.155227)\mathrm{M} = 0.034616\ \mathrm{mol/L}$$

$$[N_2O_4] = (0.18289 + 0.155227)\ \mathrm{M} = 0.338117\ \mathrm{mol/L}$$

Step 5. Rearrange the equation for the ideal gas:

$$PV = nRT \Leftrightarrow P = \frac{n}{V} \times RT = [x] \times RT$$

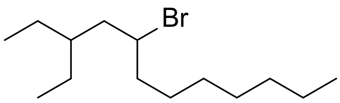
to calculate the pressures for NO_2 and N_2O_4 at chemical equilibrium:

$$P_{NO_2} = (0.034616\ \mathrm{mol/L}) \times (0.08206\mathrm{L} \times \mathrm{atm/K} \times \mathrm{mol}) \times (353.15\mathrm{K}) = 1.00\ \mathrm{atm}$$

$$P_{N_2O_4} = (0.338117\ \mathrm{mol/L}) \times (0.08206\mathrm{L} \times \mathrm{atm/K} \times \mathrm{mol}) \times (353.15\mathrm{K}) = 9.80\ \mathrm{atm}$$

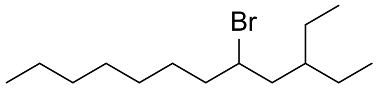
Problem 4a

Identical:



A

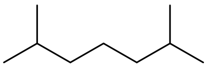
5-bromo-3-ethyldodecane



G

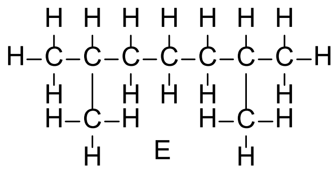
5-bromo-3-ethyldodecane

Identical:



B

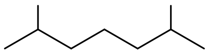
2,6-dimethylheptane



E

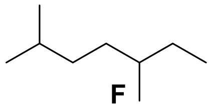
2,6-dimethylheptane

Constitutional isomers:



B or **E**

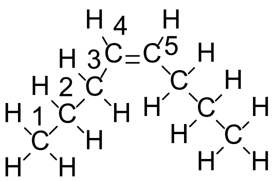
2,6-dimethylheptane
C_9H_{20}



F

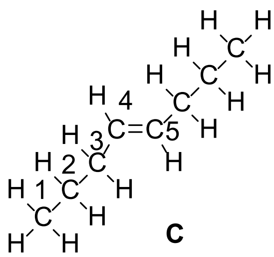
2,5-dimethylheptane
Chemical Formula: C_9H_{20}

Geometric isomers:



H

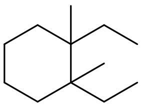
Chemical Formula: C_8H_{16}



C

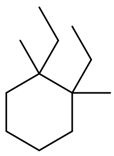
Chemical Formula: C_8H_{16}

Identical:



I

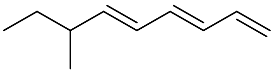
1,2-diethyl-1,2-dimethylcyclohexane



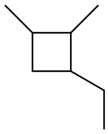
J

1,2-diethyl-1,2-dimethylcyclohexane

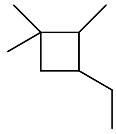
Problem 4b

(a) 

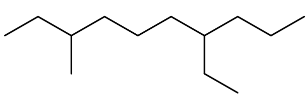
7-methylnona-1,3,5-triene
(7-metylnon-1,3,5-trie)

(b) 

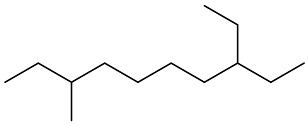
1-ethyl-2,3-dimethylcyclobutane
(1-etyl-2,3-dimetylsyklobutan)

(c) 

3-ethyl-1,1,2-trimethylcyclobutane
(3-etyl-1,1,2-trimetylsyklobutan)

(d) 

7-ethyl-3-methyldecane
(7-etyl-3-metyldekan)

(e) 

3-ethyl-8-methyldecane
(3-etyl-8-metyldekan)

Problem 4c

Step 1. The half-reactions of the cell reaction:

$$2Al(s) + 3Ni^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Ni(s)$$

are

Anode reaction: $Al(s) \rightarrow Al^{3+}(aq) + 3e^{-}$

Cathode-reaction: $Ni^{2+}(aq) + 3e- \rightarrow Ni(s)$

Step 2. The cell-diagram is:

$Al(s) | Al^{3+}(aq) || Ni^{2+}(aq) | Ni(s)$

d.