Djilali Bounaama University, Khemis Miliana

Matter and Computer Sciences Faculty

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Chemistry Department

Physico-Chemical Analysis Techniques

Exercise Series 1

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Problem 1

We study the sedimentation of a red blood cell in blood (Plasma) under the effect of gravity.

1. Draw the diagram and analyze all the forces acting on the red blood cell.
2. Calculate the sedimentation velocity (v1) in the blood.
3. What is the time (t) required for the red blood cell to travel 10 cm?

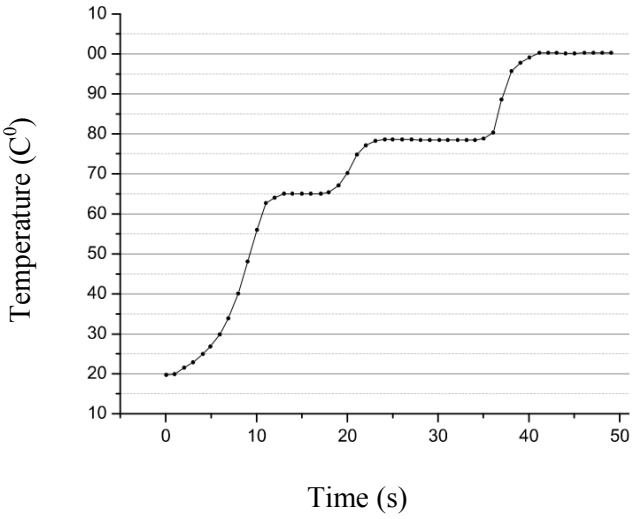
Now we study the sedimentation of a red blood cell in blood through centrifugation.

4. Provide the expression for the sedimentation velocity v2 of the red blood cell as a function of acceleration (γ).
5. Given that the average radius of centrifugation is r = 10 cm, and the rotation speed of the centrifuge is (ω = 15000 revolutions/min), calculate the centrifugal acceleration, then the sedimentation velocity v2 of the red blood cell.
6. Compare quantitatively v1 and v2.

Given: $\rho_{GR} = 1.30.10^3$ kg/m^3 , r $_{GR} = 2$ µm, $\rho_{Plasma} = 1.06.10^3$ kg/m^3 , $\eta_{Plasmaa} = 10^{-3}$ Pa.s and g = 9.81m/s^2

Problem 2:

During the distillation of a mixture of unknown components, the graph below was obtained. It represents the variation of the temperature at the top of the column as a function of time. Determine the components of this mixture using the table and the graph below.



SUBSTANCES:
Acetone
Benzene
Chloroform
Water
Ethanol
Methanol,
Carbon Tetrachloride (Tetra chlorométhane : francais)

Problem 3:

The partition coefficient of iodine (I_2) between two immiscible solvents, tetrachloromethane and water, is equal to 100 at 25°C. To 10 ml of an aqueous iodine solution at 10 g/L, 10 ml of tetrachloromethane (CCl_4) is added.

- Determine the concentration of iodine in tetrachloromethane and in water after decantation.

Given: I_2 is more soluble in tetrachloromethane than in water.

Problem 4:

We want to extract benzoic acid from a beverage using a solvent. We have three solvents available: dichloromethane, ethanol, and diethyl ether.

Solvent	Eau	Dichloromethane	ethanol	diethyl ether
Solubility (benzoic acid)	Poor	Average	Good	Good
Density	1	1.3	0.8	0.6
Miscibility in water	/	Immiscible	miscible	Immiscible

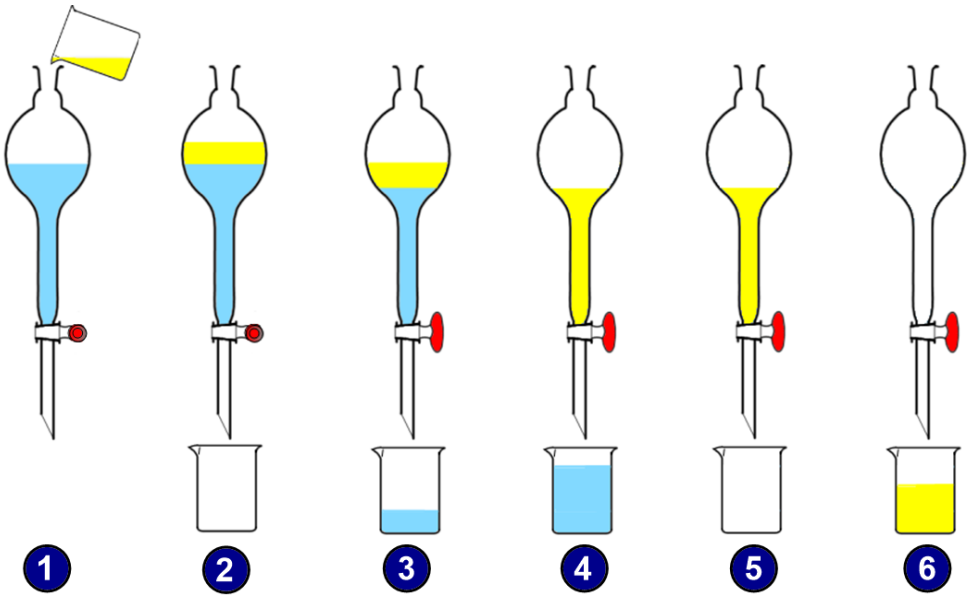
2- Which solvent is suitable for this operation (extraction)?

3- In a separatory funnel, we introduce a volume V_0=40 of the solution S_0 of benzoic acid with an initial concentration of solute $C_0=10^{-2}$ mol/L. What is the amount of substance of benzoic acid?

4- We add a volume V=10 ml of dichloromethane. The funnel is sealed, shaken, and the mixture is allowed to settle. Describe what is observed, providing justification.

5- We collect V_1=40 ml of the aqueous phase and titrate the benzoic acid it contains using a sodium hydroxide solution. The concentration of benzoic acid in this aqueous phase is $C_{aq}=10^{-3}$ mol/L. What is the amount of benzoic acid remaining in this aqueous phase? Deduce the amount transferred into the organic phase and its concentration.

6- Calculate the partition coefficient k and the extraction yield.



Polar Solvents

Name	Molecular Formula	Dipole Moment (D)	Boiling Point (°C)	Density (g/mL)	Appearance
Methanol	CH_3OH	1.70	64.7	0.79	Colorless
Ethanol	C_2H_5OH	1.69	78.37	0.79	Colorless
Acetone	$(CH_3)_2CO$	2.88	56.05	0.79	Colorless
Water	H_2O	1.85	100	1.00	Colorless
Acetonitrile	CH_3CN	3.92	81.6	0.79	Colorless
Dimethyl Sulfoxide (DMSO)	$(CH_3)_2SO$	3.96	189	1.10	Colorless
Tetrahydrofuran (THF)	C_4H_8O	1.63	66	0.89	Colorless
Dimethylformamide (DMF)	C_3H_7NO	3.82	153	0.95	Colorless
Isopropanol	C_3H_8O	1.66	82.6	0.79	Colorless
Ethylene Glycol	$C_2H_6O_2$	2.30	197.3	1.11	Colorless
Glycerol	$C_3H_8O_3$	2.60	290	1.26	Colorless
Formamide	CH_3NO	3.73	210	1.13	Colorless
N-Methyl-2-pyrrolidone (NMP)	C_5H_9NO	4.09	202	1.03	Colorless
Methoxyethanol	$C_3H_8O_2$	1.80	124	0.96	Colorless
Pyridine	C_5H_5N	2.19	115.2	0.98	Colorless to Yellow
Propylene carbonate	$C_4H_6O_3$	4.94	242	1.20	Colorless
Nitrobenzene	$C_6H_5NO_2$	4.22	210.9	1.20	Pale Yellow
Acetic Acid	CH_3COOH	1.74	118.1	1.05	Colorless
Butanol	$C_4H_{10}O$	1.66	117.7	0.81	Colorless
Cyclohexanol	$C_6H_{12}O$	1.67	161.1	0.96	Colorless

Non-Polar Solvents

Name	Molecular Formula	Dipole Moment (D)	Boiling Point (°C)	Density (g/mL)	Appearance
Hexane	C_6H_{14}	0.00	68.7	0.66	Colorless
Toluene	C_7H_8	0.36	110.6	0.87	Colorless
Benzene	C_6H_6	0.00	80.1	0.88	Colorless
Diethyl Ether	$C_4H_{10}O$	1.15	34.6	0.71	Colorless
Chloroform	$CHCl_3$	1.04	61.2	1.48	Colorless
Carbon Tetrachloride	CCl_4	0.00	76.7	1.59	Colorless
Cyclohexane	C_6H_{12}	0.00	80.7	0.78	Colorless
Petroleum Ether	C_5H_{12} (variable)	0.00	36-60	0.64-0.66	Colorless
n-Heptane	C_7H_{16}	0.00	98.4	0.68	Colorless
n-Octane	C_8H_{18}	0.00	125.6	0.70	Colorless
Dichloromethane (DCM)	CH_2Cl_2	1.60	39.6	1.33	Colorless
Carbon Disulfide	CS_2	0.00	46.3	1.26	Colorless
Tetrafluoromethane	CF_4	0.00	-128	1.96 (gas at STP)	Colorless
Ethylbenzene	$C_6H_5C_2H_5$	0.60	136.2	0.87	Colorless
Decane	$C_{10}H_{22}$	0.00	174.1	0.73	Colorless
Pentane	C_5H_{12}	0.00	36.1	0.63	Colorless
Nonane	C_9H_{20}	0.00	150.8	0.72	Colorless
Cyclopentane	C_5H_{10}	0.00	49.2	0.75	Colorless
Isooctane	C_8H_{18}	0.00	99.2	0.69	Colorless
1,2-Dichloroethane	$C_2H_4Cl_2$	1.80	83.5	1.25	Colorless

1. Aqueous phase

The aqueous phase refers to the part of a system in which water is the main solvent. It typically contains solutes dissolved in water and is characterized by its hydrophilic properties. For example, in a liquid mixture, the aqueous phase is the part where water is predominant.

2. Organic phase

The organic phase refers to the part of a system where an organic solvent (non-aqueous) is used, such as hydrocarbons, alcohols, or ethers. This phase often contains organic compounds and is hydrophobic, meaning it does not mix well with water.

3. Solution

A solution is a homogeneous mixture of two or more substances in which one substance (the solute) is dissolved in another (the solvent). For example, salt dissolved in water constitutes a saline solution.

4. Suspension

A suspension is a heterogeneous mixture in which small solid particles are dispersed in a liquid but are not completely dissolved. The particles will eventually settle at the bottom if the suspension is left to rest. For example, a mixture of water and sand is a suspension.

5. Colloid

A colloid is a dispersed system in which particles of one material (colloidal) are dispersed in another material (usually a liquid) and have a size between that of a solution and that of a suspension. Colloidal particles do not easily settle and can remain suspended for long periods. A common example of a colloid is milk.

6. Homogeneous solution

A homogeneous solution is a solution in which the solute is evenly distributed throughout the solvent, such that the entire mixture has a uniform composition. For example, a solution of sugar dissolved in water, where the sugar is completely dissolved.

7. Heterogeneous solution

A heterogeneous solution is a mixture whose components are not uniformly distributed. In a heterogeneous solution, it is possible to visually distinguish or physically separate the different phases or components. For example, vinaigrette containing oil and vinegar is a heterogeneous solution.