ID code: | | | | | | | | | | | |

Chemistry Entrance Exam (Sample)

To be completed by the evaluator

1. What is the **primary** bond type between particles broken in the following processes? (*Select the correct bond type from the list and write its number in the box.*)

a) When grinding table salt crystals ☐

b) When the water evaporates ☐

c) When cutting a piece of sodium ☐

d) When burning sulphur ☐

e) When iodine is dissolved in ether ☐

☐

10p

Bond types:

1. Metallic bond
2. Hydrogen bond
3. Ionic bond
4. Intramolecular forces
5. Polar covalent bond
6. Non-polar covalent bond

2. How do the following factors influence the equilibrium of a chemical reaction $NH_4Cl(t) \overset{t^\circ}{\rightleftarrows} NH_3\,(g) + HCl\,(g)$ ($\Delta H > 0$) and rate of **forward** (left to right) reaction (*tick the correct boxes*)?

Factors	Equilibrium			Rate of forward reaction		
	does not shift	shifts to the left	shifts to the right	decreases	increases	does not change
Grinding of NH_4Cl						
Removal of NH_3						
Addition of HCl						
Decreasing temperature						
Decreasing pressure						

☐

10p

3. Write the chemical formulas of the appropriate reactants or products in the following reaction equations and balance the reaction equations. (The symbol (aq) indicates the substance is in an aqueous solution.)

a) $HCl(aq) + Fe \rightarrow$ _____

b) _____ $\rightarrow NaOH(aq) + H_2\uparrow$

c) $Ca(HCO_3)_2(aq) + HNO_3(aq) \rightarrow$ _____

d) _____ $\rightarrow Ca_3(PO_4)_2\downarrow + H_2O$

e) $CuSO_4(aq) + Zn \rightarrow$ _____

☐

15p

To be completed by the evaluator

4. Which of the following compounds (i.e., select two substances) can react with each other in aqueous solution?

- hydrochloric acid
- silver nitrate
- potassium nitrate
- sodium sulphide

Write (and balance) reaction equations (**molecular and net ionic equations**) for the three possible reactions of the selected substances.

12p

1. _____

_____

2. _____

_____

3. _____

_____

5. A. Calculate the amount of oxygen atoms (in moles) in

a) 44,8 dm^3 gaseous nitrogen dioxide (STP).

b) 426 g aluminium nitrate.

5p

Answer: a) There are _____ moles of oxygen in nitrogen dioxide.

b) There are _____ moles of oxygen in aluminium nitrate.

B. Which contains **less** oxygen, 1 mol nitrogen dioxide or 1 mol aluminium nitrate? (*Underline the correct answer.*)

Justify your answer:

2p

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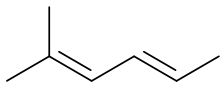
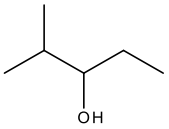
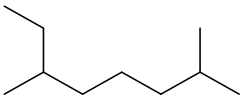
To be completed by the evaluator

6. A. a) Fill in the table.

Nr.	Name of the compound	Structural formula	Classes of organic compound	Hydrogen bond
1.	2-aminobutane			☐
2.				☐
3.			carboxylic acids	☐
4.	pentanal			☐
5.				☐
6.			amino acids	☐
7.	potassium butanoate			☐
8.				☐
9.			arens	☐
10.			haloalkanes	☐

☐ *15p*

b) Which substance(s) in the table contains (contain) hydrogen bonds (*mark "+" in the last column of the table*)?

B) Choose two compounds from the table that form hydrogen bonds and use structural formulas to illustrate how:

a) one substance forms hydrogen bonds between its molecules and

b) another substance forms hydrogen bonds with water.

☐ *6p*

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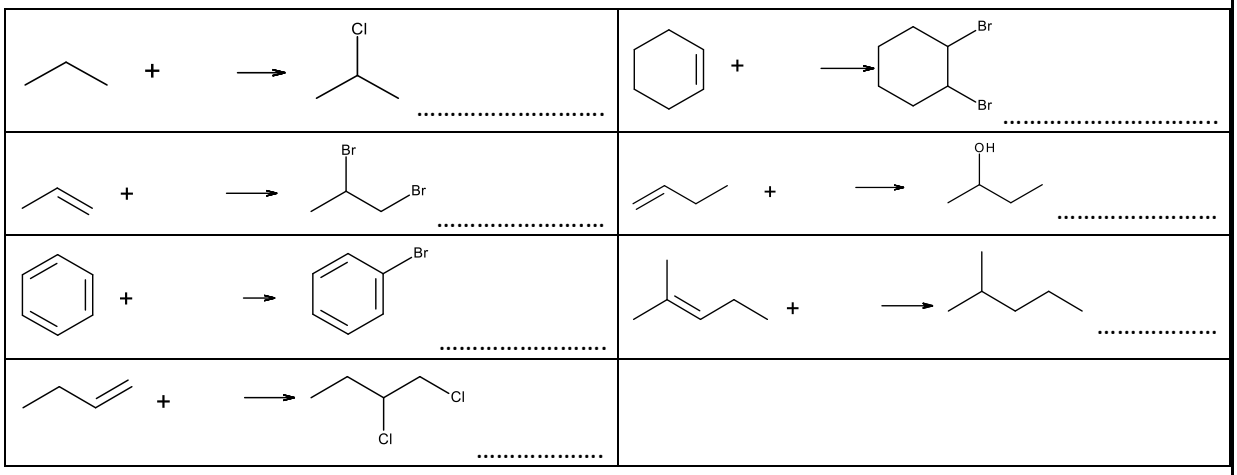
To be completed by the evaluator

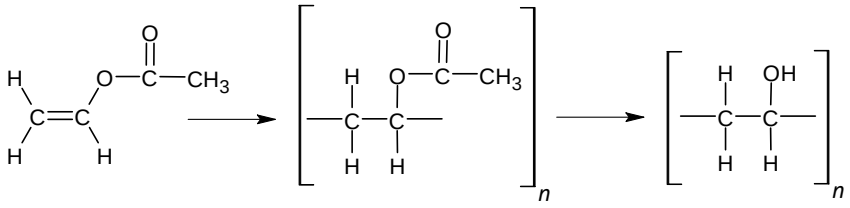
7. Choose the correct reagents and conditions (in parentheses) from the list below to obtain the following products. If an additional product is formed, write it on the dotted line.



Reagents: Br_2 (+ $FeBr_3$), Cl_2 (+ radiation), Br_2, H_2O (+ H^+), Cl_2, H_2 (+ cat).

7p

8. Polyethenol (polyvinyl alcohol) is a water-soluble polymer. One of the starting reagents for producing polyvinyl alcohol is ethenyl ethanoate (vinyl acetate).



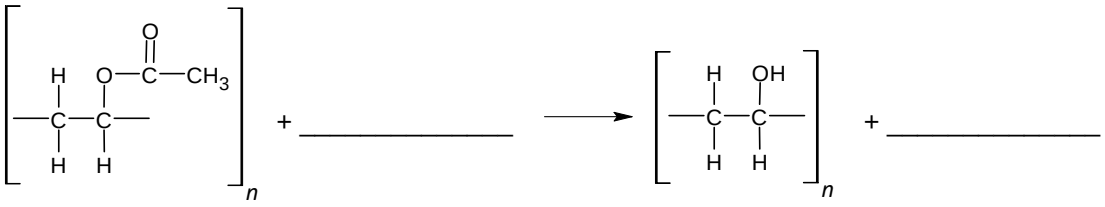
vinyl acetate polyvinyl acetate polyvinyl alcohol

A. Choose the reaction class from below that can be used to convert vinyl acetate into polyvinyl acetate and underline it.

Reaction class:

1) neutralisation
2) condensation polymerisation
3) addition polymerisation
4) dehydrogenation
5) hydrolysis
6) dehydration

B. Write the reaction equation to produce polyvinyl alcohol from polyvinyl acetate.



polyvinyl acetate polyvinyl alcohol

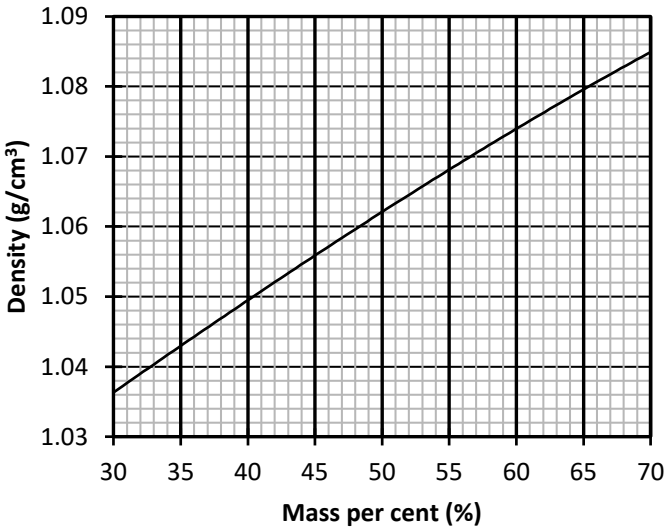
Which reaction class does this reaction belong to? (*Write the number of the correct reaction class from part A of the problem in the blank space.*) _____

4p

To be completed by the evaluator

9. Ethylene glycol (ethane-1,2-diol) is used in coolants and antifreeze because its aqueous solution has a low freezing point. For example, a 35% aqueous ethylene glycol solution freezes at −20 °C.

A. Calculate how many moles of ethylene glycol are contained in 1 dm^3 of fresh antifreeze (i.e. find the molar concentration of a 35% ethylene glycol solution). The dependence of the density of an aqueous solution of ethylene glycol on the mass percentage is shown in the graph.



5p

B. Calculate the mass per cent of ethylene glycol in the coolant used after 120 cm^3 of water has evaporated from the fresh 1 dm^3 coolant given in Part **A**.

2p

Answer: A. 1 dm^3 of fresh antifreeze contains _____ moles of ethylene glycol.

B. The mass per cent of ethylene glycol in the coolant used was _____.

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To be completed by the evaluator

10. 15,0 moles of tetra phosphorus decaoxide (P_4O_{10}) were reacted with 1.8 kg of water. Water was in excess compared to tetraphosphorus decaoxide.

A. a) Write the reaction equation for that process and calculate how many moles of phosphoric acid were produced in the reaction if 12% P_4O_{10} dissipated without reacting.

4p

b) Calculate the yield per cent of the reaction.

B. Calculate how many moles of water remained unreacted.

3p

Answer: A. a) _____ moles of product were formed.

b) The yield per cent of the reaction was _____.

B. _____ moles of water remained unreacted.

Periodic Table of Elements

	I A	II A											III A	IV A	V A	VI A	VII A	VIII A
1.	1 **H** 1																1 **H** 1	2 **He** 4
2.	3 **Li** 7	4 **Be** 9											5 **B** 11	6 **C** 12	7 **N** 14	8 **O** 16	9 **F** 19	10 **Ne** 20
3.	11 **Na** 23	12 **Mg** 24	III B	IV B	V B	VI B	VII B	VIII B			I B	II B	13 **Al** 27	14 **Si** 28	15 **P** 31	16 **S** 32	17 **Cl** 35,5	18 **Ar** 40
4.	19 **K** 39	20 **Ca** 40	21 **Sc** 45	22 **Ti** 48	23 **V** 51	24 **Cr** 52	25 **Mn** 55	26 **Fe** 56	27 **Co** 59	28 **Ni** 59	29 **Cu** 63,5	30 **Zn** 65	31 **Ga** 70	32 **Ge** 73	33 **As** 75	34 **Se** 79	35 **Br** 80	36 **Kr** 84
5.	37 **Rb** 85,5	38 **Sr** 88	39 **Y** 89	40 **Zr** 91	41 **Nb** 93	42 **Mo** 96	43 **Tc** 99	44 **Ru** 101	45 **Rh** 103	46 **Pd** 106	47 **Ag** 108	48 **Cd** 112	49 **In** 115	50 **Sn** 119	51 **Sb** 122	52 **Te** 128	53 **I** 127	54 **Xe** 131
6.	55 **Cs** 133	56 **Ba** 137	57 **La** 139	72 **Hf** 179	73 **Ta** 181	74 **W** 184	75 **Re** 186	76 **Os** 190	77 **Ir** 192	78 **Pt** 195	79 **Au** 197	80 **Hg** 201	81 **Tl** 204	82 **Pb** 207	83 **Bi** 209	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7.	87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (282)	112 **Cn** (285)						
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.

Atomic Number

Atomic Mass

Lanthanoids: 57 – 71

Actinoids: 89 – 112

Metal Activity Series

K Ba Ca Na Mg Al Mn Zn Cr Fe Ni Sn Pb **H** Cu Hg Ag Pt Au

Solubility Table

	K^+	Na^+	Li^+	NH_4^+	Ag^+	Ba^{2+}	Ca^{2+}	Mg^{2+}	Mn^{2+}	Ni^{2+}	Zn^{2+}	Cu^{2+}	Pb^{2+}	Fe^{2+}	Fe^{3+}	Al^{3+}	Cr^{3+}
OH^-	L	L	L	L	—	L	VL	E	E	E	E	E	E	E	E	E	E
Cl^-	L	L	L	L	E	L	L	L	L	L	L	L	VL	L	L	L	L
Br^-	L	L	L	L	E	L	L	L	L	L	L	L	E	L	L	L	L
I^-	L	L	L	L	E	L	L	L	L	L	L	—	E	L	L	L	L
S^{2-}	L	L	L	—	E	L	VL	L	E	E	E	E	E	E	—	—	—
SO_3^{2-}	L	L	L	L	E	E	E	E	E	E	E	E	E	E	—	—	—
SO_4^{2-}	L	L	L	L	VL	E	VL	L	L	L	L	L	E	L	L	L	L
PO_4^{3-}	L	L	VL	L	E	E	E	E	E	E	E	E	E	E	E	E	E
CO_3^{2-}	L	L	L	L	E	E	E	E	E	E	E	E	E	E	—	—	—
SiO_3^{2-}	L	L	E	—	E	E	E	E	E	E	E	E	E	E	E	E	E
NO_3^-	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

L – soluble in water

VL – slightly soluble in water

E – practically insoluble in water

— – unstable in water