P1 1	Name: ____________________ Student code: __________	P1 1

1.1 You started with 2.54 g of polycarbonate. Determine the theoretical yield of bisphenol A in g. (2 points)

M_1 (polycarbonate) = M_1 $(C_{16}H_{14}O_3)_nH_2$ ≈ M_1 $(C_{16}H_{14}O_3)$ = 254.30 g/mol

m_1 = 2.54 g

M_2 $(C_{15}H_{16}O_2)$ = 228.31 g/mol

$m_2 = m_1 \cdot M_1^{-1} \cdot M_2$

Theoretical yield of bisphenol A: 2.28 **g**

exact answer: *2 points*; incorrect mathematical rounding, more or less than two figures after the decimal point (e.g. 2.3 g, 2.281 g): *1 point*; wrong or missing answer: *0 points*.

1.2 Determine your theoretical yield of bisphenol A bis(carboxymethyl)ether in g based on 2.00 g bisphenol A. (2 points)

M_2 $(C_{15}H_{16}O_2)$ = 228.31 g/mol

m_2 = 2.00 g

M_3 $(C_{19}H_{20}O_6)$ = 344.39 g/mol

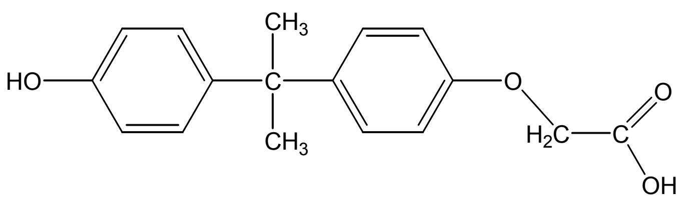
$m_3 = m_2 \cdot M_2^{-1} \cdot M_3$

Theoretical yield of bisphenol A bis(carboxymethyl)ether: 3.02 **g**

exact answer: *2 points*; incorrect mathematical rounding, more or less than two figures after the decimal point (e.g. 3.0 g, 3.017 g): *1 point*; wrong or missing answer: *0 points*.

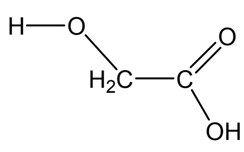
1.3 Unwanted by-products are possible in the second step. Write down the structural formulas of two most probable unwanted by-products. (6 points)

1. Bisphenol A reacts only once with sodium chloroacetate (monosubstitution):



(3)

2. Alkaline hydrolysis of sodium chloroacetate:



(3)

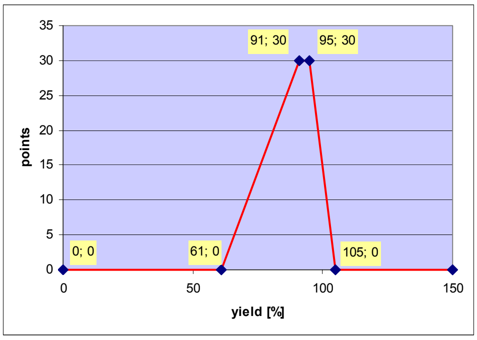
For each of the two answers - exact structural formula: *3 points*, one careless mistake: *1 point less*, two careless mistakes: *2 points less*, wrong or missing answers: *0 points.*

P1$_2$ Grading scheme for mentors only P1$_2$

1.4 Step 1, yield [%] of the product measured by the organizer: (30.0 points)

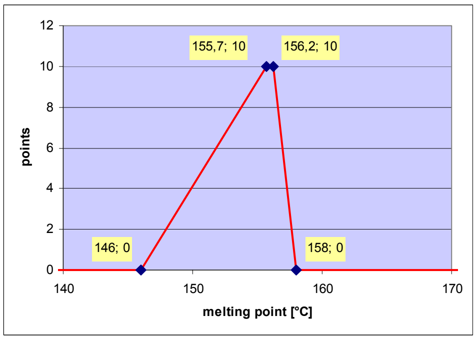
$f(x) = 0$	$x < 61$	
$f(x) = x - 61$	$61 \le x \le 91$	
$f(x) = 30$	**$91 < x \le 95$**	**master value**
$f(x) = -3x + 315$	$95 < x \le 105$	
$f(x) = 0$	$x > 105$	

$m_2 \cdot M_1 \cdot m_1^{-1} \cdot M_2^{-1} \cdot 100 = x$ [%]



1.5 Step 1, melting point [°C] of the product measured by the organizer: (10.0 points)

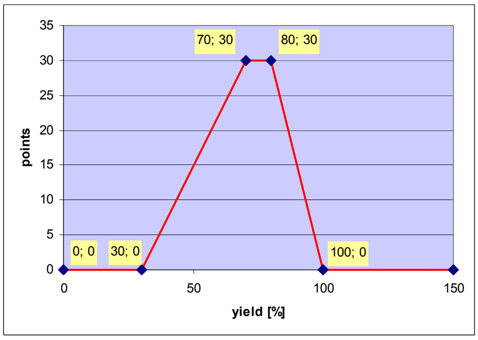
$f(x) = 0$	$x < 146.0$	
$f(x) = +1.03093\,x + 150.51546$	$146.0 \le x < 155.7$	
$f(x) = 10$	**$155.7 \le x \le 156.2$**	**master value**
$f(x) = -5.55556\,x + 877.77778$	$156.2 < x \le 158.0$	
$f(x) = 0$	$x > 158.0$	



1.6 Step 2, yield [%] of the product measured by the organizer: (30.0 points)

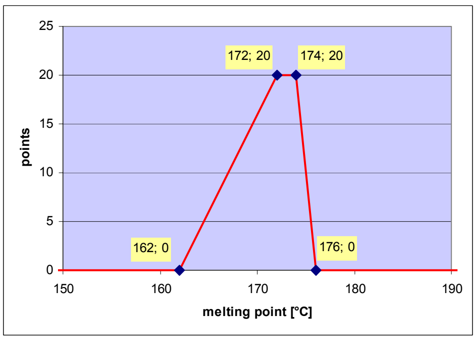
$f(x) = 0$	$x < 30$	
$f(x) = 0.75\,x - 22.5$	$30 \le x \le 70$	
$f(x) = 30$	**$70 < x \le 80$**	**master value**
$f(x) = -1.5\,x + 150$	$80 < x \le 100$	
$f(x) = 0$	$x > 100$	

$m_3 \cdot M_2 \cdot m_2^{-1} \cdot M_3^{-1} \cdot 100 = x$ [%]



1.7 Step 2, melting point [°C] of the product measured by the organizer: (20.0 points)

$f(x) = 0$	$x < 162$	
$f(x) = 2x - 324$	$162 \le x \le 172$	
$f(x) = 20$	**$172 < x \le 174$**	**master value**
$f(x) = -10x + 1760$	$174 < x \le 176$	
$f(x) = 0$	$x > 176$	



A penalty of 10 points will be given if melting point tubes are not filled by the student.

Accuracy of points for 1.4 – 1.7: rounding value is one digit after the decimal point.

P2₁	Name: ______________________ Student code: ___________	P2₁

2.1 Which alkaline earth metal(s) can be found in the superconductor? Mark only one box! (30)

Ca	□	(0)	**Sr**	□	(0)	**Ba**	x	(30)
Ca and Sr	□	(0)	**Ca and Ba**	□	(5)	**Sr and Ba**	□	(15)
Ca and Sr and Ba	□	(10)						

Complete the following reaction equations: **(2)**

$Ca^{2+} + C_2O_4^{2-} \rightleftharpoons CaC_2O_4$ (0.5)

$Sr^{2+} + CO_3^{2-} \rightleftharpoons SrCO_3$ (0.5)

$2\,Ba^{2+} + [Cr_2O_7]^{2-} + H_2O \rightleftharpoons 2\,BaCrO_4 + 2\,H^+$ (1)

2.2 Quantitative determination of the total content of lanthanum and copper. **(35)**

Titration No.	$V_{initial}$ (mL)	V_{final} (mL)	V (mL)
1			
2			
3			
...			
...			
...			

appropriate consumption of 0.1000 mol L^{-1} EDTA solution V = 11.60***mL**
(accoding to 100 mL of superconductor solution)

2.3 Quantitative determination of the copper content. **(35)**

Titration No.	$V_{initial}$ (mL)	V_{final} (mL)	V (mL)
1			
2			
3			
...			
...			
...			

appropriate consumption of 0.01000 mol L^{-1} $Na_2S_2O_3$ solution V = 10.50* **mL**
(according to 100 mL of superconductor solution)

Complete the following reaction equations: **(3)**

$2\,Cu^{2+} + 4\,I^- \rightleftharpoons I_2 + 2\,CuI$ (2)

$I_2 + 2\,S_2O_3^{2-} \rightleftharpoons 2\,I^- + S_4O_6^{2-}$ (1)

* The correct master values will be given to you later,
values with two digits after the decimal point otherwise -1 point

2.4 Mass (in mg) of copper in your parent solution, mass (in mg) of lanthanum in your parent solution. **(3)**

[M(Cu) = 63.55 g mol^{-1}; M(La) = 138.91 g mol^{-1}]

Amount of copper:
10,50 mL · 0.01 mol L^{-1} · 4 · 10 · 63.55 g mol^{-1} = 266.9 mg (1)

Amount of lanthanum:
[11.60 - (10.50/10 · 4)] mL · 0.1 mol L^{-1} · 10 · 138.91 g mol^{-1} = 1028 mg (2)

mass Cu **m(Cu)** **=** 266.9 **mg**
mass La **m(La)** **=** 1028 **mg**

2.5 Assume a fictive consumption of 39.90 mL of 0.1000 mol L^{-1} EDTA solution and 35.00 mL of 0.01000 mol L^{-1} $Na_2S_2O_3$ solution. Calculate the coefficient x in the formula $La_xM_{(2-x)}CuO_4$ (M = Ca and/or Sr and/or Ba) and give the exact formula of the superconductor **(5)**

consumption for lanthanum = [39.90 – (35.00/10 · 4)] mL = 25.90 mL (2)
consumption for copper = (39.90 – 25.90) mL = 14.00 mL (2)

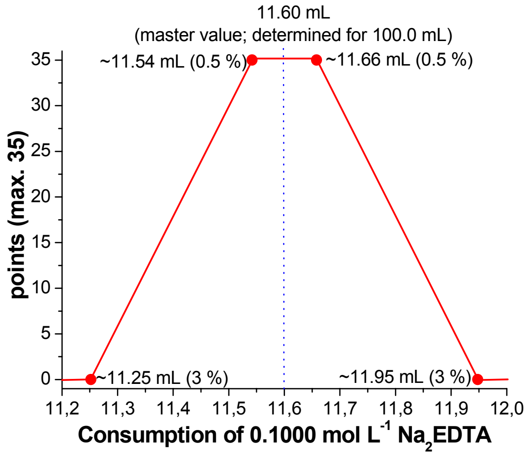
n(La) : n(Cu) = 25.90 : 14.00 = 1.85 : 1

coefficient x: 1.85 **formula:** $La_{1.85}Ba_{0.15}CuO_4$ (1)

2.2 Complexometric Titration (35.0 points)

$$P = 35 \cdot \left[1 - \frac{|(C1 - (MV1 \cdot PS/100)| - ((MV1 \cdot PS/100) \cdot 0.005)}{((MV1 \cdot PS/100) \cdot 0.03) - ((MV1 \cdot PS/100) \cdot 0.005)} \right]$$

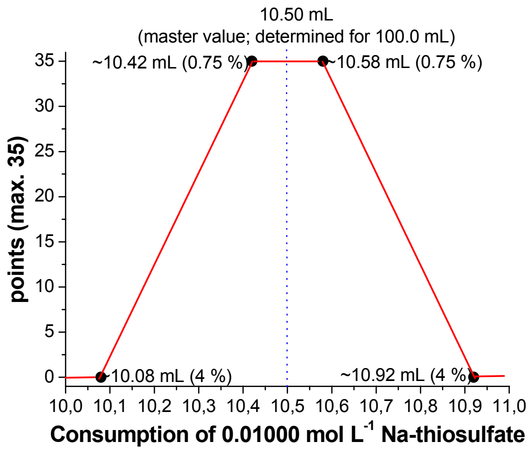
P = points
C1 = experimental consumption (mL)
MV1 = actual master value
PS = mL of superconductor solution handed out (100.0, 99.00, 98.00, 97.00 mL)
if P ≥ 35 use the maximum points of 35
if P ≤ 0 use zero points



2.3 Iodometric Titration (35.0 points)

$$P = 35 \cdot \left[1 - \frac{|(C2 - (MV2 \cdot PS/100)| - ((MV2 \cdot PS/100) \cdot 0.0075)}{((MV2 \cdot PS/100) \cdot 0.04) - ((MV2 \cdot PS/100) \cdot 0.0075)} \right]$$

P = points
C2 = experimental consumption (mL)
MV2 = actual master value
PS = mL of superconductor solution handed out (100.0, 99.00, 98.00, 97.00 mL)
if P ≥ 35 use the maximum points of 35
if P ≤ 0 use zero points



Accuracy of points for 2.2 and 2.3: rounding value is one digit after the decimal point.