Incoherent Light Sources

M. Sc. Chemical Engineering / Photonics

July 20th, 2018

Prof. Dr. Thomas Jüstel

Name: _____

Enrolment number: _____

Day of Birth: _____

Please keep in mind to clearly figure out the solution approach and the results. Please solely use IUPAC units.

Duration 180 Minutes

Allowed aids: Periodic table of the elements, pocket calculator, Dieke diagram, formulaic collection math

Points		**Mark**	
Task 1:	10 Points	1,0	95 – 100 Points
Task 2:	10 Points	1,3	90 – 94 Points
Task 3:	10 Points	1,7	85 – 89 Points
Task4:	10 Points	2,0	80 – 84 Points
Task5:	10 Points	2,3	75 – 79 Points
Task6:	10 Points	2,7	70 – 74 Points
Task7:	10 Points	3,0	65 – 69 Points
Task8:	10 Points	3,3	60 – 64 Points
Task9:	10 Points	3,7	55 – 59 Points
Task10:	10 Points	4,0	50 – 54 Points
		5,0	0 – 49 Points

Success!

Task 1 **(10 Points)**

Physical Basis of Light Generation

a) Please sketch the principle of light generation by electroluminescence! (4 Points)

b) Please explain the expression „cathodoluminescence“! In which technical devices is such process of importance? (3 Points)

c) Please explain the following expressions? (1 Point each)

- Incandescence
- Luminescence
- Stokes Shift

Task 2 **(10 Points)**

Terms from Lighting Technology

a) Please explain the following photometric and radiometric quantities and mention the respective physical units! (1 Point each)

Term	**Explanation**	**Unit**
Radiant flux		
Luminous flux		
Irradiance		
Illuminance		

b) Please define the energy efficiency and the light efficiency of an electrical light source! (2 Points)

Task 3 **(10 Points)**

Incandescence and Halogen Lamps

a) Sketch the spectrum of an incandescent/halogen incandescent lamp! (3 Points)

b) What chemical transport reactions do occur in halogen and incandescent lamps? (3 Points)

c) Calculate the wavelengths at which the emission of a black body is maximal for 3000 and 6000 K using Wien's displacement law! (2 Points)

Wien's displacement law: $\lambda_{max} = 2880 / T$ [µm*K]

d) Name two technical measures to increase the lifetime of an incandescent lamp? (2 Points)

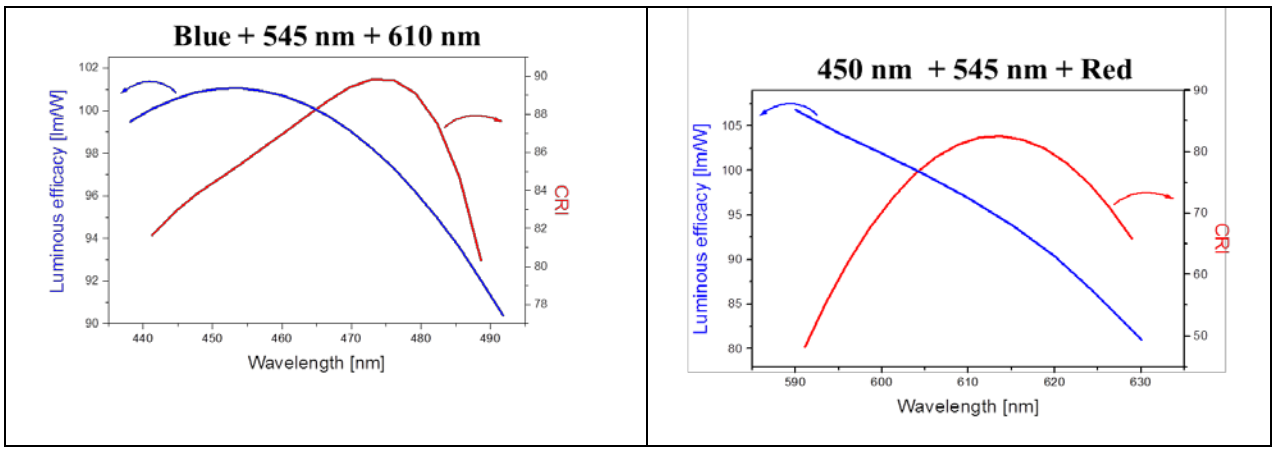
Task 4 **(10 Points)**

Low-Pressure Discharge Lamps

a) Name two chemical elements which are often used in low-pressure discharge lamps! Please explain your choice! (2 Points)

b) Please sketch the light generation chain in a linear fluorescent lamp! (4 Points)

c) The following graphs show the luminous efficacy and CRI of a trichromatic fluorescent lamp. Please name the consequences for the choice of the blue and red emitting component with respect to the light yield and CRI of such lamps? (2 Points)



d) Name two phosphors, which are used in low-pressure Hg discharge lamps! (2 Points)

Task 5 **(10 Points)**

High-Pressure Discharge Lamps

a) Please explain the origin of the spectral shift of a low-pressure Hg discharge with increasing pressure? (3 Points)

b) Calculate the energy efficiency ε of a Hg high-pressure lamp using YVO_4:Eu as a phosphor taking into consideration the following data: discharge efficiency = 40% with 30% visible emission, 10% UV emission at 365 nm, which is completely converted to line emission of YVO_4:Eu at 615 nm, quantum efficiency of the phosphor at λ_{365} = 90%! (4 Points)

c) Please name two application areas of high-pressure lamps and explain the advantage of such lamps over low-pressure lamps! (3 Points)

Task 6 **(10 Points)**

Luminescence Mechanisms

a) Please explain the term energy transfer and give an example! (2 Points)

b) Please explain the term sensitisation with a self-imposed example! (2 Points)

c) Please argue the importance of lanthanide ions as activators in many phosphors! (2 Points)

d) Please name the dominant quenching mechanism of the photoluminescence for the following activators! (4 Points)

a) Ce^{3+}
b) Eu^{3+}
c) Tb^{3+}
d) Bi^{3+}

Task 7 **(10 Points)**

Inorganic Luminescent Materials

a) Which activators ions are suitable for the following emission ranges? (6 Points)

- UV-C
- UV-B
- UV-A
- Blue
- Green
- NIR

b) Please explain the impact of lattice defects on the performance and properties of inorganic luminescent materials! (2 Points)

c) What is an afterglow pigment? Give an example and argue your choice! (2 Points)

Task 8 **(10 Points)**

Inorganic Light Emitting Diodes (ILEDs)

a) $(Ga_{1-x}In_x)N$ and $(Ga_{1-x}In_x)P$ are important solid solutions for semiconductor LEDs. Please sketch the course of the band gap as function of x for nitrides and phosphides. Please also compare the two solid solutions with each other! (3 Points)

b) Explain the success of III-V semiconductor LEDs with respect to lifetime and efficacy! (4 Points)

c) Please mention three processes, which govern the wall plug efficiency of an inorganic LED! (3 Points)

Task 9 **(10 Points)**

Organic Light Emitting Diodes (OLEDs)

a) Describe the process of manufacturing of two different types of OLEDs and explain the causes for the different manufacturing processes! (3 Points)

b) Explain the causes for the use of Ir^{3+} complexes in OLEDs? (3 Points)

c) Explain the light generation chain in an OLED! (4 Points)

Task 10 **(10 Points)**

UV Radiation Sources

a) Please name four types of UV radiation sources (4 Points)

b) Please name three prominent photochemical reactions and propose a suitable UV radiation source! (3 Points)

c) Calculate the energy efficiency ε of an UV radiation source based on a Xe excimer discharge (172 nm, discharge efficiency = 70%) and an UV-C phosphor (YPO_4:Pr, 235 nm, QE = 90%)! (3 Points)

Appendix: Dieke Diagram for Ln^{3+} Ions