General instructions: Theoretical Examination (30 points)

May 7, 2019

The theoretical examination lasts for 5 hours and is worth a total of 30 points.

Before the exam

- You must not open the envelopes containing the problems before the sound signal indicating the beginning of the competition.
- The beginning and end of the examination will be indicated by a sound signal. There will be announcements every hour indicating the elapsed time, as well as fifteen minutes before the end of the examination (before the final sound signal).

During the exam

- Dedicated answer sheets are provided for writing your answers. Write your answers into the appropriate tables, boxes or graphs on the corresponding answer sheet (marked A). For every problem, there are extra blank working sheets for carrying out detailed work (marked W). Be sure to always use the working sheets that belong to the problem you are currently working on (check the problem number in the header). If you have written something on any sheet which you do not want to be graded, cross it out. Only use the front side of every page.
- In your answers, try to be as concise as possible: use equations, logical operators and sketches to illustrate your thoughts whenever possible. Avoid the use of long sentences.
- Please give an appropriate number of significant figures when stating numbers.
- Often, you may be able to solve later parts of a problem without having solved the previous ones.
- A list of physical constants is given on the next page.
- You are not allowed to leave your working place without permission. If you need any assistance, please draw the attention of a team guide by raising one of your flags ("I need water" if you need water, "toilet break" if you need to go to the toilet, "Extra paper, please!" if you need extra working sheets, "equipment/materials" if you have a problem with your equipment or materials or "I need help" in all other cases).

At the end of the exam

- At the end of the examination you must stop writing immediately.
- For every problem, sort the corresponding sheets in the following order: cover sheet (C), questions (Q), answer sheets (A), working sheets (W) and then extra sheets (Z) if you have them.
- Put all the sheets belonging to one problem into the envelope for that question. Also put the general instructions (G) into the remaining separate envelope. Also hand in empty sheets. You are not allowed to take any sheets of paper out of the examination area.
- Leave your writing equipment on the table, you will use it again in the experimental exam.
- Wait at your table in silence until your envelopes are collected. Once all envelopes are collected your guide will escort you out of the examination area.

General Data Sheet

Speed of light in vacuum	c	=	$299\,792\,458\ \mathrm{m \cdot s^{-1}}$
Vacuum permeability	μ_0	=	$4\pi \times 10^{-7}\ \mathrm{kg \cdot m \cdot A^{-2} \cdot s^{-2}}$
Vacuum permittivity	ε_0	=	$8.854\,187\,817\ldots \times 10^{-12}\ \mathrm{A^2 \cdot s^4 \cdot kg^{-1} \cdot m^{-3}}$
Elementary charge	e	=	$1.602\,176\,620\,8(98) \times 10^{-19}\ \mathrm{A \cdot s}$
Mass of the electron	m_e	=	$9.109\,383\,56(11) \times 10^{-31}\ \mathrm{kg}$
Mass of the proton	m_p	=	$1.672\,621\,898(21) \times 10^{-27}\ \mathrm{kg}$
Mass of the neutron	m_n	=	$1.674\,927\,471(21) \times 10^{-27}\ \mathrm{kg}$
Atomic mass constant	m_u	=	$1.660\,539\,040(20) \times 10^{-27}\ \mathrm{kg}$
Rydberg constant	R_∞	=	$10\,973\,731.568\,508(65)\ \mathrm{m^{-1}}$
Universal constant of gravitation	G	=	$6.674\,08(31) \times 10^{-11}\ \mathrm{m^3 \cdot kg^{-1} \cdot s^{-2}}$
Acceleration due to gravity in Adelaide	g	=	$9.797\ \mathrm{m \cdot s^{-2}}$
Planck's constant	h	=	$6.626\,070\,040\ (81) \times 10^{-34}\ \mathrm{kg \cdot m^2 \cdot s^{-1}}$
Avogadro number	N_A	=	$6.022\,140\,857\ (74) \times 10^{23}\ \mathrm{mol^{-1}}$
Molar gas constant	R	=	$8.314\,4598(48)\ \mathrm{kg \cdot m^2 \cdot s^{-2} \cdot mol^{-1} \cdot K^{-1}}$
Molar mass constant	M_u	=	$1 \times 10^{-3}\ \mathrm{kg \cdot mol^{-1}}$
Boltzmann constant	k_B	=	$1.380\,648\,52(79) \times 10^{-23}\ \mathrm{kg \cdot m^2 \cdot s^{-2} \cdot K^{-1}}$
Stefan-Boltzmann constant	σ	=	$5.670\,367\ (13) \times 10^{-8}\ \mathrm{kg \cdot s^{-3} \cdot K^{-4}}$