Trinity College NST Admissions Guidance

Prior to interviews, we will ask you to decide on your current main school subject interest, from a choice of **Biology**, **Chemistry** and **Physics**. We will ensure that at least one of your interviewers will be a specialist in your main subject interest. The remaining interviewer(s) will ask you further questions in areas which match your school subject background – either one of the other subjects you have studied or more general scientific and mathematical questions (or both).

If you are invited to interview, you will be asked to sit an interview preparation paper, the contents of which will be discussed during one interview. For in-person interviews, this will be taken in College and you will then take your answers with you to your interview. For candidates being interviewed remotely, it will be taken under conditions of remote invigilation. Please do not share or discuss questions asked of you in this at-interview assessment or at interview.

The interview preparation paper you will see will contain two sections of about four questions each. One section will be about your main subject interest and the other section will contain further questions about a different subject or more general mathematics or science questions.

The interview preparation paper is not another exam, but rather a chance for you to see what topics are likely to come up at interview and to give you more time to prepare to answer our interview questions, rather than being put on the spot in the interview itself. Whilst we realise that sitting what may well feel like an examination is not pleasant, we hope that the interview preparation paper will actually make the interview experience a little less daunting for you.

The questions on the paper will be of different lengths and styles. Some questions may be structured, while others will be deliberately open-ended to leave room for discussion later. Some may well be easier than others, but remember that the length of a question and its difficulty are not necessarily correlated. You should not worry about the style of the various questions too much: as mentioned above, the paper is not a written examination and will not be marked as such; instead, it is intended to be used as a starting point for a discussion at interview, and different styles of question help us to test different skills.

We do not necessarily expect you to be able to answer all parts of all questions. Often, even if a question has a clear 'correct' answer, the actual aim of the question might be different from what it may seem at first glance, as e.g. thinking about the limitations of an approach can provide a springboard for discussion at interview, or the interview might focus on a less obvious but more elegant solution. By contrast, a question may also appear quite unusual when you see it for the first time: there are certainly questions which few if any candidates can answer during the test, but by attempting them, you will be in a good position to make solid progress in the interview itself, and we are especially interested in understanding your approach and style of thinking when approaching such questions. This is in many ways not dissimilar to the way supervisions work. The important thing is not to panic when you encounter questions that might initially look a little peculiar.

Interviewers will on the whole prefer to see a few questions attempted more fully rather than sketchy answers to many questions. While the interview preparation paper can give you some idea of topics that are likely to be touched upon at interview, you should not be surprised if you are asked further or unrelated questions at interview.

For interviews in Biology in particular, the questions in the interview preparation paper provide an indication of your knowledge baseline to your interviewers. Biology interviews are thus more likely than others to cover further unrelated material, and you might perhaps even be shown a video or a prop in the interview to stimulate discussion.

Below, we give some example questions to give you a flavour of what kind of paper to expect. We have split the questions by subject, but there are more sections and more questions in the following than you will be presented with in the interview preparation paper itself.

Natural Sciences
Interview Preparation Paper

[sample paper]

Time allowed: **60 minutes**

You are **not** expected to answer all questions in the allocated time. They are difficult and you should concentrate on getting fewer, complete questions out rather than many fragments.

Do not write essays. Use brief notes to list the main points you regard as important.

Calculators may be used, but it is expected that they will only be used for numerical evaluation.

The paper comprises *two sections* of four questions each. It would be in your interest to attempt to answer at least one question from each section.

[To give you a flavour of questions set in recent years, this sample paper contains more questions than a typical interview preparation paper, and more sections than the above rubric indicates.]

You may not open this paper until instructed to do so.

Fundamental constants

A list of some physical constants is provided below. Their listing does not imply that they will necessarily be used in any questions. Where information is not given in a question, appropriate estimates should be made.

Name	Symbol	Value (uncertainty)		Unit
speed of light in vacuum*	c	2.997 924 58	$\times 10^{8}$	m s^{-1}
Planck constant*	h	6.626 070 15	$\times 10^{-34}$	J s
reduced Planck constant*	$\hbar$	1.054 571 817 ...	$\times 10^{-34}$	J s
Avogadro constant*	N_A	6.022 140 76	$\times 10^{23}$	mol^{-1}
elementary charge*	e	1.602 176 634	$\times 10^{-19}$	C
electron mass	m_e	9.109 383 701 5(28)	$\times 10^{-31}$	kg
proton mass	m_p	1.672 621 923 69(51)	$\times 10^{-27}$	kg
neutron mass	m_n	1.674 927 498 04(95)	$\times 10^{-27}$	kg
unified atomic mass unit	u	1.660 539 066 60(50)	$\times 10^{-27}$	kg
Faraday constant*	F	9.648 533 212 ...	$\times 10^{4}$	C mol^{-1}
molar gas constant*	R	8.314 462 618 ...		J mol^{-1} K^{-1}
Boltzmann constant*	k_B	1.380 649	$\times 10^{-23}$	J K^{-1}
vacuum electric permittivity	ε_0	8.854 187 812 8(13)	$\times 10^{-12}$	C V^{-1} m^{-1}
vacuum magnetic permeability	μ_0	1.256 637 062 12(19)	$\times 10^{-6}$	N A^{-2}
Stefan–Boltzmann constant*	σ	5.670 374 419 ...	$\times 10^{-8}$	W m^{-2} K^{-4}
gravitational constant	G	6.674 30(15)	$\times 10^{-11}$	m^{3} kg^{-1} s^{-2}
standard acceleration of gravity*	g_0	9.806 65		m s^{-2}
standard atmosphere*	atm	1.013 25	$\times 10^{5}$	Pa

CODATA recommended values (2018). The estimated standard uncertainty (in brackets) applies to the least significant digit. Quantities marked with an asterisk are exact and have no associated error.

Other constants and conversion factors

Description	Symbol	Value	Unit
radius of the Earth at the equator	R_E	6.378×10^{6}	m
specific heat capacity of water at 25 °C and 1 atm	c_P	4.180	kJ kg^{-1} K^{-1}
density of water at 4 °C and 1 atm	ρ_W	1.000	kg dm^{-3}

1 kcal = 4.184 kJ

0 °C = 273.15 K

1 L = 1 dm^{3}

1 Å = 10^{-10} m

Periodic table of the elements

Z A_r Symbol

Standard relative atomic masses from IUPAC technical report 2013.
Synthetic elements shown in grey.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 1.008 H																	2 4.0026 He
2	3 6.94 Li	4 9.0122 Be											5 10.81 B	6 12.011 C	7 14.007 N	8 15.999 O	9 18.998 F	10 20.18 Ne
3	11 22.99 Na	12 24.305 Mg											13 26.982 Al	14 28.085 Si	15 30.974 P	16 32.06 S	17 35.45 Cl	18 39.948 Ar
4	19 39.098 K	20 40.078(4) Ca	21 44.956 Sc	22 47.867 Ti	23 50.942 V	24 51.996 Cr	25 54.938 Mn	26 55.845(2) Fe	27 58.933 Co	28 58.693 Ni	29 63.546(3) Cu	30 65.38(2) Zn	31 69.723 Ga	32 72.630(8) Ge	33 74.922 As	34 78.971(8) Se	35 79.904 Br	36 83.798(2) Kr
5	37 85.468 Rb	38 87.62 Sr	39 88.906 Y	40 91.224(2) Zr	41 92.906 Nb	42 95.95 Mo	43 — Tc	44 101.07(2) Ru	45 102.91 Rh	46 106.42 Pd	47 107.87 Ag	48 112.41 Cd	49 114.82 In	50 118.71 Sn	51 121.76 Sb	52 127.60(3) Te	53 126.9 I	54 131.29 Xe
6	55 132.91 Cs	56 137.33 Ba	57–71 La–Lu	72 178.49(2) Hf	73 180.95 Ta	74 183.84 W	75 186.21 Re	76 190.23(3) Os	77 192.22 Ir	78 195.08 Pt	79 196.97 Au	80 200.59 Hg	81 204.38 Tl	82 207.2 Pb	83 208.98 Bi	84 — Po	85 — At	86 — Rn
7	87 — Fr	88 — Ra	89–103 Ac–Lr	104 — Rf	105 — Db	106 — Sg	107 — Bh	108 — Hs	109 — Mt	110 — Ds	111 — Rg	112 — Cn	113 — Nh	114 — Fl	115 — Mc	116 — Lv	117 — Ts	118 — Og

57 138.91 La	58 140.12 Ce	59 140.91 Pr	60 144.24 Nd	61 — Pm	62 150.36(2) Sm	63 151.96 Eu	64 157.25(3) Gd	65 158.93 Tb	66 162.5 Dy	67 164.93 Ho	68 167.26 Er	69 168.93 Tm	70 173.05 Yb	71 174.97 Lu
89 — Ac	90 232.04 Th	91 231.04 Pa	92 238.03 U	93 — Np	94 — Pu	95 — Am	96 — Cm	97 — Bk	98 — Cf	99 — Es	100 — Fm	101 — Md	102 — No	103 — Lr

Chemistry

C1. Discuss the nature of the interaction between (a) the chlorine atoms in the molecule Cl_2; (b) two chlorine ions in NaCl; and (c) two chlorine molecules.

C2. To determine the enthalpy of combustion of a solid sample, the sample is instantaneously burnt in a sealed container filled with excess oxygen, and we measure the temperature change of the surrounding medium (typically water), which is itself placed in an insulated outer container.

A 1.00 g compressed tablet of benzoic acid was burnt in a calorimeter and this resulted in a recorded temperature rise of 1.76 K. The heat of combustion of benzoic acid is 26.454 kJ g^{-1}.

In a separate experiment in the same calorimeter, a 2.00 g tablet of tartaric acid (2,3-dihydroxybutane-dioic acid) was burnt and the recorded temperature rose by 1.0264 K.

Determine the molar enthalpy of combustion of tartaric acid at room temperature, making clear any assumptions or approximations made.

C3. A spherical room of radius R = 5 m is filled with air and is held at a constant temperature of 300 K, but is otherwise completely isolated from the rest of the universe. The number density of dry air at 300 K is 2.5×10^{25} molecules m^{-3}.

Civetone is a pheromone of molecular mass 250 u that is often used in perfumes. Suppose a small amount of civetone is sprayed at the centre of the room, generating a compact spherically symmetric cloud of individual civetone molecules.

Approximately how long will it take for the perfume to be able to be smelt at the walls? You may find dimensional analysis to be a helpful tool in your calculation. You may assume any gravitational effects are negligible.

To what extent would your answer change if the room were not isolated?

$$\left[\quad 1\,\mathrm{u} = 1.661 \times 10^{-27}\,\mathrm{kg} \qquad\qquad k_B = 1.381 \times 10^{-23}\,\mathrm{J\,K^{-1}} \quad\right]$$

C4. Three isomeric compounds have the molecular formula C_3H_4. Draw possible structures showing how the atoms are arranged in space and comment on the bonding in each compound.

C5. What is the average separation between atoms or molecules in a gas at 1 atm and 273 K?

C6. Comment on the following statements.

(a) An electrolytic cell can be set up with chromium as the anode and an object we wish to electroplate as the cathode in a $CrCl_3$ electrolyte solution. However, the analogous process with sodium is not feasible.

(b) Calcium carbonate is poorly soluble in water and its solubility decreases as the temperature increases. Dissolving ammonium nitrate in water is an endothermic process, and yet ammonium nitrate is readily soluble.

Physics

P1. A golfer driving from the tee swings his club so that the head completes a (virtually) complete circle in 0.5 s. Make a reasoned estimate of the maximum distance he could hit the ball.

P2. You are provided with a positively charged ball suspended by an insulating thread and two uncharged metal cans. Describe the sequence of operations you would carry out to charge one can positively and the other can negatively.

P3. According to Newton's law of cooling, the temperature of an object decreases at a rate proportional to the difference between its temperature and that of the surroundings. If the constant of proportionality is $100\,\mathrm{s}^{-1}$, estimate the time it takes for a freshly brewed cup of coffee to become drinkable.

P4. Seen from the Moon, the Earth has 3.6 times the angular diameter of the Sun. What is the ratio of densities of the Sun and the Earth?

Biology

B1. In maize, one gene determines leaf size (big or small) and another determines pollen colour (yellow or orange). A cross between a plant with big leaves and yellow pollen and a plant with small leaves and orange pollen gave the following progeny.

leaf size	pollen colour	number
big	yellow	163
big	orange	144
small	yellow	48
small	orange	54

What are the probable genotypes of the parents?

B2. (a) When a cell divides during development, its two daughters adopt different fates: one becomes skin and the other becomes muscle. Suggest two different hypotheses for the way in which this could be achieved.

(b) Design experiments to distinguish between these hypotheses.

B3. An approximation to the air pressure on Earth at a given altitude is given by

$$p = p_0 \exp\left(-\frac{Mg}{RT}d\right),$$

where p_0 is the air pressure at sea level, M is the molar mass of dry air ($0.02896\,\mathrm{kg\,mol^{-1}}$), T is the standard sea-level temperature (288.15 K) and d is the distance above sea level in metres.

(a) Assume that a human at rest (minimal energy use) exhales the same volume of air as inhaled, but with a 4 % absolute reduction in oxygen composition of that air, i.e.

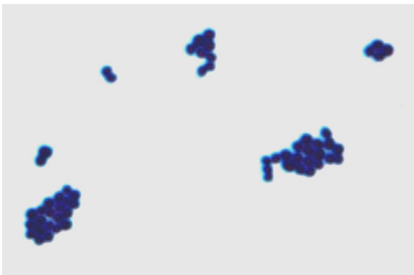
$$\text{(percentage oxygen in inhaled air)} - \text{(percentage oxygen in exhaled air)} = 4.$$

Assume also that the human body could extract all the oxygen from inhaled air if required, but that the extraction rate cannot increase. Under these assumptions, what would be the maximum altitude at which a human could survive indefinitely at rest?

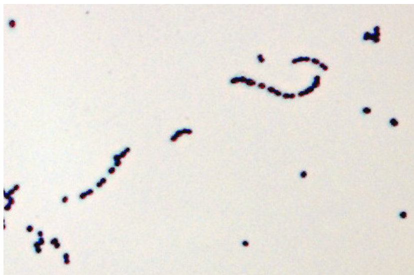
(b) The height of Mount Everest above sea level is approximately 8849 m. A human at rest at the summit of Mount Everest breathing the atmosphere there will eventually die from hypoxia. Suggest reasons for this.

(c) Suggest physiological responses and techniques that may make a trip to the summit of Mount Everest survivable.

B4. The figure below shows photographs of two different microscope slides. In each case the slide has been made by taking a smear from a colony of bacteria, as indicated, and staining the smear with a stain that allows individual bacteria to be seen (a Gram stain).



Staphylococcus aureus



Streptococcus pyogenes

(a) Describe the morphological differences you can see between the two slides.

(b) Bearing in mind that the slide images are in effect two-dimensional projections of three-dimensional colony structures, comment on what the morphological differences you have described may imply for the patterns of division in the two species.

(c) Suggest experiments that may test your answer to the previous part.

(d) Suggest underlying mechanisms that may control these division patterns.

General science and mathematics

G1. A region R of the (x, y) plane is defined as follows. It has $x > 0$ and $y > 0$. Its boundary consists of finite sections of the following three curves: the y axis, the curve $y = x^2$ and a circle of radius $\sqrt{2}$ centred on the origin. What is the area of R?

G2. Sketch the graph of $f(x) = \arctan(x) + \arctan(1/x)$.

G3. A certain medical condition affects one in a thousand of the population. A screening procedure is developed that is 95 % accurate. Discuss the probability that you have the condition if the screening procedure says that you do.

G4. Why does a clear sky on Earth appear blue and a cloudy sky white? Why is copper sulphate blue when hydrated and white when anhydrous?

END OF PAPER