S6 Combined Science Practice Paper (Set 2): Radioactivity and Nuclear Energy, Transformers and Transmission, Immunity and Vaccines, Genetics and Genetic Engineering, Ecology and Diversity, Scientific Investigation and Uncertainty (100 marks)

Level: S6 | Subject: Combined Science | 75 minutes | 100 marks | 24 questions | question paper

Part 1 Radioactivity and Nuclear Energy (16 marks)

Show all formulae, substitutions and calculation steps.

#	Question	Marks
1	A radioactive source has an initial activity of 640 Bq and a half-life of 8 days. Find the activity in Bq after 24 days and after 40 days.	4
2	After 32 days a sample has decayed to one thirty-second of its original activity. Find its half-life in days.	4
3	One fission event has a mass defect of 3.2 x 10^-28 kg. Taking c = 3.0 x 10^8 m/s, find the energy released in joules (3 significant figures) and in MeV (1 MeV = 1.602 x 10^-13 J).	4
4	1.0 g of uranium-235 undergoes complete fission, releasing 2.88 x 10^-11 J per nucleus (molar mass 235 g/mol, Avogadro constant 6.022 x 10^23). Find the total energy in joules and the equivalent mass of coal in kg and tonnes (coal: 30 MJ per kg).	4

Part 2 Electromagnetic Induction and Transformers (16 marks)

Give units for every numerical answer and use the significant figures requested.

#	Question	Marks
5	A transformer has 1200 turns on the primary and 60 turns on the secondary, with 220 V across the primary. Find the secondary voltage in V.	4
6	The same transformer delivers 5.0 A at the secondary with an efficiency of 95%. Find the output power in W, the input power in W (3 s.f.) and the primary current in A (3 s.f.).	4
7	A transmission cable has a total resistance of 0.5 ohm and carries 20 A. Find the power lost in the cable in W. If the transmitted power is unchanged but the voltage is raised 10 times, find the new current, the new loss in W, and the factor by which the loss falls.	4
8	A 200-turn coil has the flux through it rise uniformly from 0.002 Wb to 0.008 Wb in 0.05 s. Find the induced e.m.f. in V; if the coil resistance is 8 ohm, find the induced current in A (2 s.f.).	4

Part 3 Immunity and Vaccines (17 marks)

State the formula and assumptions used, and explain what the result means.

#	Question	Marks
9	A serum sample starts at 1:80 and is then serially diluted 1:2 five times. Find the final dilution factor.	4
10	For an infection with R0 = 6, find the percentage of the population that must be immune for herd immunity (1 d.p.) and the number of people in a population of 7.5 million. If R0 falls to 3, find the new percentage (1 d.p.).	4

11	In a vaccine trial the attack rate is 4.0% in the unvaccinated group and 0.8% in the vaccinated group. Find the relative risk (decimal) and the vaccine efficacy in %.	4
12	An antibody has a half-life of 21 days in blood. After vaccination its concentration is 1200 units per mL. Find the concentration after 84 days and explain why a booster is needed some months later.	5

Part 4 Genetics and Genetic Engineering (17 marks)

Probabilities may be given as fractions, decimals or percentages, but keep one form throughout.

#	Question	Marks
13	Two carriers of the same recessive allele (Aa x Aa) plan a family. Find the probability that a child is affected; if they have 3 children, find the probability that all 3 are unaffected (%, 1 d.p.).	4
14	For an X-linked recessive disease the mother is a carrier (X^A X^a) and the father is unaffected (X^A Y). Find the probability that a son and a daughter are affected, and explain the daughters.	4
15	PCR starts from 10 DNA copies and doubles every cycle. Find the number of copies after 30 cycles (3 s.f.) and explain why doubling again after 40 cycles matters little in practice.	4
16	On a gel a 100 bp fragment migrates 60 mm and a 1000 bp fragment 20 mm (distance is linear in log10 size). Find the migration distance of a 600 bp fragment in mm (3 s.f.) and explain how the method confirms a PCR product.	5

Part 5 Ecological Succession and Diversity (17 marks)

For ecology questions, write the index formula and compare the two sets of data.

#	Question	Marks
17	In an ecosystem producers fix 45000 kJ, primary consumers 4500 kJ, secondary consumers 450 kJ and tertiary consumers 45 kJ. Find the transfer efficiency at each level and explain what it means.	4
18	Lincoln index: 80 animals are marked and released, then 60 are caught of which 12 are marked. Estimate the population and state one factor that makes the estimate too high.	4
19	Two quadrats of equal area. Quadrat A: species A 50, B 30, C 20. Quadrat B: A 80, B 10, C 10. Using Simpson index D = 1 - sum(n/N)^2, find D for both (2 d.p.) and say which is more diverse.	4
20	A succession survey records 3 species at year 0, 9 at year 10, 18 at year 50 and 22 at year 100. Find the mean rate of change in species number for each interval (species per year), identify the fastest interval and explain why.	5

Part 6 Scientific Investigation and Uncertainty (17 marks)

For uncertainty questions, write the percentage-error or combination formula first.

#	Question	Marks
21	A length is measured as 12.4 cm with an instrument uncertainty of plus or minus 0.05 cm. Find the percentage error (%, 2 s.f.).	4
22	Mass is 45.2 +/- 0.1 g and volume 18.0 +/- 0.2 cm3. Find the density in g/cm3 (3 s.f.) with its percentage and absolute uncertainty.	4

23	A spring gives 0.98 N at 0.02 m extension, 1.96 N at 0.04 m, 2.94 N at 0.06 m and 3.92 N at 0.08 m. Find the spring constant in N/m and explain how the data support Hooke law.	4
24	The true length is 5.10 cm and four readings are 5.02, 5.04, 5.01 and 5.03 cm. Find the mean, the sample standard deviation in cm (3 s.f.), the percentage difference from the true value, and comment on accuracy and precision.	5

TutorZone - original practice paper. Time allowed: 75 minutes. Total: 100 marks.