PRIFYSGOL ABERYSTWYTH UNIVERSITY

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DEPARTMENT OF PHYSICS

SEMESTER 2 EXAMINATIONS, MAY 2026

PH33810 – Materials Physics

Time allowed – 2 hours

- **Full marks can be attained for complete answers to ALL six questions in Section A and TWO questions from Section B**
- **The numbers in brackets after the questions indicate the allocation of marks for each question.**
- **Only calculators from the Casio FX83, FX85 or FX991 range may be used.**
- **A booklet of mathematical formulae and standard constants will be provided.**
- **Only a 1 side of A4 summary sheet is allowed.**
- **MAE MODD I FYFYRWYR GYFLWYNO ATEBION I'R PAPUR HWN NAILL AI YN Y GYMRAEG NEU'R SAESNEG**
- **STUDENTS MAY SUBMIT ANSWERS TO THIS PAPER IN EITHER WELSH OR ENGLISH**

Once seated, students may complete the front cover of the answer book(s) and the attendance slip ONLY.

DO NOT TURN THE EXAMINATION QUESTION PAPER OVER UNTIL INSTRUCTED TO DO SO.

Section A

Attempt ALL questions in the booklet provided

1 Categorise the following nano-assembly methods as being either "bottom-up" or "top-down"- [5]

i) Polymersome formation

ii) Laser cutting/ablation

iii) Photolithography

iv) Wet chemical etching

v) Colloidal synthesis (e.g. Stöber process)

2 Assess which of the following microscopy techniques is best suited to investigate the corrosion of a steel panel exposed to sea water: Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM), Scanning Electron Microscopy (SEM) or Transmission Electron Microscopy (TEM). Explain your choice briefly by explaining the relative merits of the techniques in relation to the problem to be studied. [5]

3 Superfluids are usually described as "quantum fluids". Explain why helium is likely to behave as a quantum fluid and neon as a classical fluid at low temperature. [5]

4 In the context of Nuclear Magnetic Resonance (NMR), what is the significance of *spin-relaxation* in Magnetic Resonance Imaging (MRI) applications? [5]

5 Use a sketch, showing a cross-section of a two-dimensional ionic crystal, to illustrate what is meant by- [5]

i) A Frenkel defect.

ii) A Schottky defect.

6 A particular milk sample is found to contain fat globules with an average diameter of 1.07 (±0.62) μm. [5]

i) Estimate the polydispersity index (PDI) of the globules based on size.

ii) Suggest a suitable experimental method of determining particle dimensions, within this size-order range, in solution.

Section B

Answer TWO questions

7 a) Describe the key differences between a type-I and a type-II superconductor, including discussion of the coherence length (ζ) and penetration depth (λ) in your answer.

[5]

b) Sketch a phase-diagram (H-field vs. temperature) for a type-II superconductor, marking on the sketch the critical fields H_{c1} and H_{c2}, and the critical temperature T_c. Identify which regions on the diagram correspond to the two different phases of superconductivity and to the "normal" phase.

[5]

c) Describe the nature of the internal magnetic field, B, in each of the three phases described in part b).

[3]

d) In a particular type-II superconductor at $T < T_c$, $H_{c1} = 0.1$ Tesla and $H_{c2} = 25$ Tesla. Hence, calculate the ratio of λ/ζ.

[2]

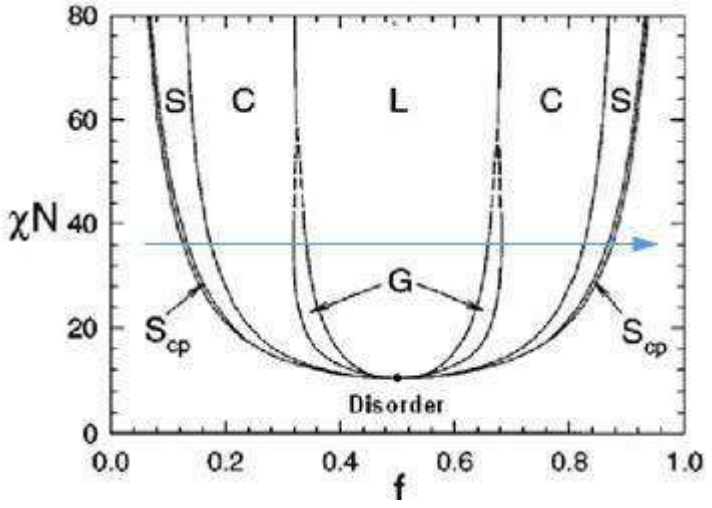
8 a) What is meant by the *phase separation* of a polymer blend? Outline the thermodynamic factors (relating to energy and entropy) which determine the phase separation of unbranched polymers A and B at given values of Φ (volume fraction of A in B) and temperature, describing the key role of Gibbs free energy (ΔG).

[8]

b) How do these thermodynamic considerations change when the polymers are bonded together to form AB-type copolymers?

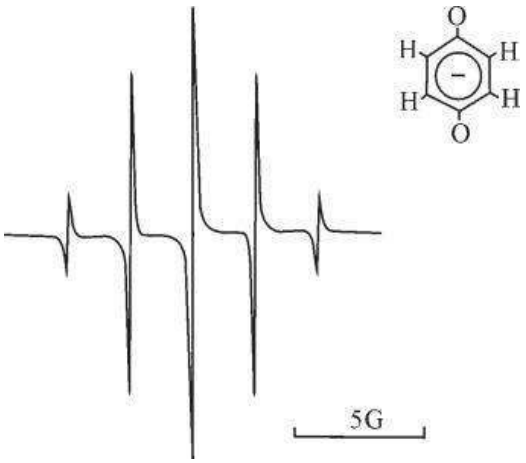
[2]

c) The phase diagram of a block (AB-type) copolymer is shown below, as a function of A/B block ratio, *f*, and Flory-Huggins interaction parameter χ. Briefly describe the changes in phase behaviour and morphology, moving from left to right along the horizontal arrow on the diagram.



[5]

9 The figure below shows the recorded absorption spectrum (differential absorption vs. applied magnetic field) of the benzoquinone anion radical (see inset for structure), recorded using an electron spin resonance (ESR) spectrometer operating at 10 GHz.



a) What is meant by the hyperfine interaction in the context of ESR? Why do the ESR spectra of molecular radicals therefore usually contain multiple resonances, as above?

[4]

b) Using an appropriate value for the electron spin g-factor, calculate the central B-field value, which must be used to obtain the above spectrum.

[3]

c) From the information in the graph, estimate the hyperfine coupling constant, *a*, in this experiment.

[2]

d) Specifically, explain why the spectrum above consists of 5 lines, and hence determine in what ratio the relative intensities of these lines should appear.

[6]

(You may assume the Bohr magneton, μ_B, has the value 9.24×10^{-24} J/T)

END OF PAPER