

Semi-Finals Introduction and Disclaimer

These mock examination questions span diverse disciplines and are designed for your practice in preparation for the International Research Olympiad (IRO) 2024. Endeavor to answer them to the best of your ability, utilizing this opportunity to enhance your skills and knowledge. For additional practice, it is advisable to engage in extensive reading of various papers; such efforts will contribute to a more comprehensive and nuanced understanding of the subject matter.

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Try your best, and good luck! -International Research Olympiad 2024

Paper 1: Materials Science, Condensed Matter Physics

Question 1

Why are superconductors valued in numerous scientific fields?

(Select all that apply)

- a) **Lack of resistance**
- b) Cold temperatures
- c) High levels of ferromagnetism
- d) **Superdiamagnetism**

→ Correct answers are directly supported by the text. Superdiamagnetism is synonymous with perfect diamagnetism.

Question 2

According to the paper, what evidence is there of room-temperature superconductivity?

(Select one)

- a) There is strong experimental evidence corroborated by the electronic structure of LK-99
- b) There is weak experimental evidence of room temperature superconductivity in the physics community
- c) **There is strong experimental evidence but many questions remain unanswered regarding the electronic structure of LK-99**
- d) DFT calculations have been performed by other researchers which support room-temperature superconductivity

→ This is explicitly supported in the introduction of the paper.

Question 3

Using the figure, what answer choices correspond to either the domain or the range of Zinc?

(Select all that apply)

- a) $(-0.1, 0.07)$ eV
- b) **$(-0.65, -0.25)$ eV**
- c) **(0, 35) States/eV**
- d) (0, 55) States/eV

→ Domain will be some interval of numbers in units of eV, and range will be some interval in the form of States/eV

Question 4

Using the figure, select the answer choices that correspond to either the domain or the range of copper

(Select all that apply)

- a) $(-0.1, 0.7) \text{ eV}$
- b) $(-0.1, 0.7) \text{ States/eV}$
- c) $(0, 55) \text{ eV}$
- d) $(0, 55) \text{ States/eV}$

Question 5

What units would be used to quantify areas in the above figure?

(Select one)

- a) eV
- b) States/eV
- c) **States**
- d) eV^2

→ To find the units of area, we need to multiply the units of the x and the y axis.

Question 6

Which of the following is true regarding LK-99 superconductors?

(Select all that apply)

- a) T_c is only at or above room temperature under high pressure
- b) T_c is at or above room temperature at all pressures
- c) T_c is at or above room temperature under ambient pressure
- d) LK-99 is a hydride superconductor
- e) **LK-99 has been doped with copper**

Question 7

How does figure C relate to figure E?

(Select one)

- a) **Zooming out along the y-axis of figure E, we obtain figure C**
- b) Zooming out along the origin of Figure E, we obtain figure C
- c) Zooming out along the origin of Figure C, we obtain figure E
- d) Zooming in along the x-axis of Figure C, we obtain figure E

Question 8

At what approximate energy is the peak DOS of the sum of Cu-d and O-p

(Select one)

- a) -0.25 eV
- b) -0.0025 eV
- c) **-0.025 eV**
- d) 55 eV

Paper 2: Computer Science, Machine Learning

Question 1

Why does AutoKeras use a novel search algorithm rather than a black-box optimization problem?

(Select one)

- a) To link hyperparameter values
- b) **To start and to continue to use good configurations**
- c) To intentionally ignore certain configurations
- d) To prevent mutations in configurations

→ Explicitly stated in text.

Question 2

What is the first step in the core AutoKeras Workflow?

(Select one)

- a) **Analyze the training data to establish its characteristics**
- b) Create training data based on prior optimization
- c) Create channel dimensions
- d) Encode categorical data

→ Explicitly stated in text.

Question 3

Which of the following best justifies the application of data normalization, data augmentation and/or other preprocessing steps?

(Select one)

- a) **It enhances the adaptability of the model to multi-modal data and multi-task use cases**
- b) It streamlines the customization of search spaces according to user preferences.
- c) It facilitates the creation of custom neural network blocks for advanced users.
- d) It improves the interpretability of the model's predictions in complex datasets.

→ This answer aligns with the passage by addressing the need to preprocess data for diverse input types and tasks, ensuring the model's ability to handle varied data effectively.

Question 4

What libraries does the paper say AutoKeras uses as a back-end?

(Select all that apply)

- a) AutoML
- b) **Keras**
- c) Pytorch
- d) **TensorFlow**

→ Explicitly stated in text.

Question 5

Which of the following might be grouped into sub-modules?

(Select all that apply)

- a) **A single hyperparameter**
- b) **An entire model**
- c) **A layer**
- d) A multi-layer module parameter

→ Explicitly stated in text.

Question 6

Why may AutoKeras tune hyperparameters from preprocessing steps?

(Select all that apply)

- a) To get distinct data from a model to train on using text vectorization
- b) **To reduce the variance of the model**
- c) To reduce bias from cherry-picked hyperparameters in datasets
- d) **To sidestep the need for manual selection of learning rates**

→ B: This answer is supported by the statement indicating AutoKeras tunes hyperparameters from preprocessing steps, which can enhance model stability and generalization.

→ D: This choice aligns with the statement that AutoKeras tunes hyperparameters such as learning rates, aiding researchers by providing standardized training settings.

Paper 3: Neuroscience, Stroke Rehabilitation

Question 1

What is the significance of a STREAM score of 63 in predicting discharge destinations for stroke patients?

(Select one)

- a) It indicates the patient's ability to independently perform daily activities.
- b) **It marks the threshold below which the probability of being discharged home is zero.**
- c) It is the minimum score required for a patient to be considered for rehabilitation therapy.
- d) It reflects the patient's cognitive recovery post-stroke.

→ Explicitly stated in text.

Question 2

Which measures were STREAM scores significantly correlated with?

(Select all that apply)

- a) **The Box and Block Test**
- b) **The Barthel Index**
- c) **Gait speed**
- d) The Timed "Up & Go" Test

Question 3

Which three measures were found to be most able to detect change in patients?

(Select three)

- a) **STREAM**
- b) **Gait speed**
- c) **The Balance Scale**
- d) The Timed "Up & Go" Test

→ Explicitly stated in text.

Question 4

What was the range of the interrater and intrarater reliability coefficients for STREAM?

(Select one)

- a) 0.80 to 0.90
- b) **0.96 to 0.999**
- c) 0.85 to 0.95
- d) 0.70 to 0.85

→ Explicitly stated in text.

Question 5

According to the study, how does a STREAM score relate to the probability of being discharged home?

(Select one)

- a) It has no significant impact on discharge decisions.
- b) Only scores above 80 ensure discharge home.
- c) **Below a certain score, the probability of home discharge is zero, but increases with higher scores.**
- d) A high STREAM score guarantees immediate discharge home.

Question 6

Which attributes of STREAM were demonstrated through the comprehensive evaluation?

(Select all that apply)

- a) **Its robustness as a measure of stroke recovery.**
- b) **Its utility in predicting functional outcomes like gait speed and daily activities independence.**
- c) Its ability to predict cognitive recovery post-stroke.
- d) **Its sensitivity to changes over time, especially in patients with severe stroke.**

→ Explicitly stated in text.

Paper 4: Biochemistry

Question 1

What are key advantages of artificial enzymes with multiple active sites?

(Select all that apply)

- a) They allow for reactions to occur at extreme temperatures
- b) **They allow for cascade reactions in one pot without isolating intermediates**
- c) They allow for the incorporation of toxic metals safely
- d) **They have stability which allows for multiple uses**

→ B: Explicitly stated in text.

→ D: The advantage of recyclability is stated under “Artificial metalloenzymes by selective creation of a novel active site in an enzyme scaffold”

Question 2

How was the first artificial enzyme created with both a natural and an abiological catalytic site?

(Select one)

- a) Computationally designing a new protein structure
- b) Mutating residues randomly until a site is formed
- c) **Genetically modifying a lipase to introduce a new Cu binding site**
- d) Incorporating a metal complex into a cavity in the structure

→ The paper describes genetically engineering a thermophilic lipase by introducing a cysteine in a lid to create a new Cu binding site

Question 3

Which of the strategies would mostly likely be difficult for researchers when trying to design an artificial enzyme with multiple catalytic sites?

(Select one)

- a) **Ensuring proper spacing between catalytic sites**
- b) Introducing cofactors into the cavities
- c) Stabilizing the enzymes to prevent degradation
- d) Achieving high yields

→ This is stated under the introduction as an important issue to consider and it is a key design challenge

Question 4

Which of the following factors would be most important to consider for a protein scaffold when designing an artificial enzyme for pharmaceutical applications?

(Select all that apply)

- a) **Thermal stability**
- b) Shelf life
- c) Immunogenic potentials
- d) **Solvent tolerance**

→ A: The human body operates at 37°C and protein scaffolds must be stable within these temperatures.

→ D: This is very important to consider for the protein scaffold since the enzyme must work within fluids of the body and should maintain its shape within these fluids.

Question 5

Which types of chemical reactions would be most suitable to perform using an artificial enzyme?

(Select all that apply)

- a) PCR amplification
- b) Gabriel synthesis
- c) **Pericyclic reaction**
- d) **Michael addition**

→ Explicitly stated in text.

Question 6

Which spectroscopic technique is *least* useful in providing insight about an enzyme-metal nanoparticle hybrid?

(Select one)

- a) UV-Vis (Ultraviolet-visible spectroscopy)
- b) **CD (Circular dichroism) spectroscopy**
- c) EXAFS spectroscopy (Extended X-ray absorption fine structure)
- d) Raman spectroscopy

→ This type of spectroscopy would provide information on the protein secondary structure, but it would not provide information on the embedded nanoparticle sites, so this technique would be the least useful.