

Materials Science Test

2017 Princeton University Science Olympiad Invitational

TEAM SIZE: Up to 2

TIME: 50 minutes

ALLOWED RESOURCES: five sheets of paper that may contain information on both sides in any form from any source; one non-graphing calculator per team member

School Name: _____

Team # : _____

Part 1: ____ /24

Part 2: ____ /56

Total: ____ /80

INSTRUCTIONS:

- Welcome to the 2017 Princeton University Science Olympiad Invitational!! Please fill in the blanks for your school name and team number on this title page.
- There are 2 labs and one multiple choice section. Every team will use the first 5 minutes to prepare the 2nd half of Part 1, the lab. Then, 2 teams at a time will work at the next lab station on the first half of Part 1. The rest will work on Part 2, multiple choice. This will rotate every 12 minutes. Do not panic if you feel rushed for time – this test was designed to be fast-paced for all teams. Split the questions at each station with your partner and answer as much as you can!
- All answers must be written on the answer sheet.

Part I: Lab (24 points)

Some of these lab portions will take a long time to finish, so it is recommended to start on the lab section first, and as you wait for some sections to finish, solve the test questions.

Young's Modulus Lab:

1. The following set up has been provided:

You will be given a wire of unknown material, a ruler, and five 150 gram weights. The wire will be held down on one end with two wooden blocks and hanging over a pulley on the other end.

The wire will be marked with a small piece of masking tape. Record the distance between one end of the wire and the masking tape. This is your starting length, l . Note the starting position of the tape, too.

Now, add one 150 gram weight to the end of the wire. Record the change in position, x , of the masked tape relative to the starting position to the nearest 0.1mm. Repeat until a total of 750 grams have been added.

Fill out the table for the **stress** and **strain** of the wire provided in the answer sheet. Assume the diameter of the cross section of the wire is 0.280mm. Show all recorded data and calculations that lead to your answers in the answer sheet.

[6 points]

2. (Tie-Breaker) Create a plot of stress vs. strain on the grid provided in the answer booklet. Make a line of best fit, and use it to estimate Young's Modulus for the wire. Show all work.

[6 points]

Intermolecular Forces Lab

You will be given three unknown liquids, along with three coins. You will be tasked with identifying the unknown liquids.

3. Start with placing one drop of each liquid on the given surface. It is important that you only place ONE drop of each liquid. Note the time that you have placed the drops. Time how long it takes for each drop to completely evaporate. If after thirty minutes it has not evaporated completely note the change in droplet size. Fill out the given tables with relative evaporation times. Note any other observations of the liquids that would help in identifying the liquid.

[6 points]

4. The possible unknown liquids are water, a solution of hydrogen peroxide, and isopropyl alcohol. Using the past two parts and your knowledge on intermolecular forces or hydrophobicity/hydrophilicity, identify the unknowns. For full points, your claims must be back by your data and short reasoning

[6 points]

Part II: Multiple Choice and Short Answer Questions (56 points):

Materials Performance and Characterization

5. As an object grows in size, what happens to its volume and surface area (increase or decrease)? Does volume or surface area increase/decrease faster?

[3 points]

6. Yield Strength is the strength at which a material

- a. Experiences tensile failure
- b. Fails under a suddenly applied load
- c. Deforms plastically
- d. Deforms elastically
- e. Fails under cyclic loading

[2 points]

7. Creep rate is the permanent deformation under stress that is

- a. Below the yield strength of a material
- b. Above the yield strength of a material
- c. At the yield strength of a material
- d. Independent of the yield strength of a material
- e. Dependent on the extent of deformation of the material

[2 points]

8. What is the formal unit of measure of viscosity?

[2 points]

9. Describe a method that can be used to measure relative viscosities of unknown liquids using a 100 mL graduated cylinder, ruler, small steel ball, timer, a pencil, and a well-plate. Not all materials have to be used. Be concise and precise.

[3 points]

There are four primary materials: metals, ceramics, polymers, and composites. Categorize the following materials under one of the four types for 11 – 16.

10. PVC

11. Fiberglass

12. Magnesium

13. Silicon Carbide

14. Boron Oxide

15. Kevlar

[1 point each]

16. Which of the following is NOT a characteristic of a ceramic?

- a. Held by ionic and covalent bonds
- b. Brittle
- c. Very high melting point
- d. Resistant to corrosion
- e. All of these are characteristics of ceramics

[2 points]

17. What is the definitive difference between alloys and composites?

- a. Composites have higher conductivities than alloys
- b. Composites are stronger than traditional alloys
- c. Alloys are made of metals, while composites are made of nonmetals
- d. Components of a composite remain separate and distinct
- e. None of the above

[2 points]

18. Gallium has an atomic number of 31. The electron configuration of a Gallium ion with a +3 charge is:

- a. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
- b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
- c. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^1$
- d. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2 4p^1$
- e. None of the above

[2 points]

19. Which of the following is NOT a metalloid (semimetal)?

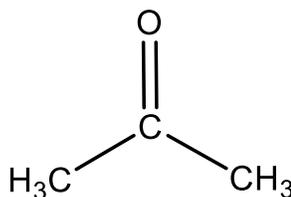
- a. Silicon
- b. Bismuth
- c. Antimony
- d. Polonium
- e. Tellurium

[2 points]

20. Which of the following is NOT in the metal alloy pewter?

- a. Antimony
- b. Copper
- c. Lead
- d. Zinc
- e. Tin

[2 points]



21. Above is a common organic solvent, acetone. What is the expected hybridization of the bond between oxygen and carbon?

- a. s-sp³
- b. p-sp²
- c. sp²-sp²
- d. sp³-sp²
- e. None of the above

[2 points]

Intermolecular Forces and Surface Chemistry

22. What is the most likely packing structure of gold?

- a. FCC
- b. BCC
- c. HCP
- d. Simple Cubic Packed
- e. None of the above

[2 points]

23. What is the primary type of bonding that holds diamond together?

- a. Metallic bonding
- b. Covalent network bonding
- c. Ionic bonding
- d. London dispersion forces
- e. Hydrogen bonding

[2 points]

24. True or False: Hydrogen bonding is always stronger than London dispersion forces for a molecule that can form hydrogen bonding.

[2 points]

25. Sodium chloride has

- a. 4 ions per unit cell, low conductivity, and high melting point
- b. 4 ions per unit cell, high conductivity, and low melting point
- c. 8 ions per unit cell, low conductivity, and high melting point
- d. 8 ion per unit cell, high conductivity, and high melting point
- e. 12 ions per unit cell, low conductivity, and low melting point

[2 points]

The following questions 26-28 are on silver:

Silver has a FCC structure. Its lattice constant, or length of an edge of the unit cell, is 4.086 Å.

26. (Tie-breaker) Calculate the distance (in Å) between the centers of the two closest silver atoms:

[5 points]

27. Calculate the atomic radius of silver:

[3 points]

28. What is the coordination number of metallic silver?

- a. 4
- b. 6
- c. 8
- d. 10
- e. 12

29. Titanium has a lattice constant of 3.306 Å and density of 4.401 g/cm³. USE these values to calculate the mass (in g) of a unit cell of titanium.

[3 points]

30. (Tie-Breaker) Describe a supercritical fluid, including the conditions necessary for it to exist

[3 points]

31. A water droplet and hydrophobic surface results in:

- a. A contact angle $< 90^\circ$
- b. A contact angle $= 90^\circ$
- c. A contact angle $> 90^\circ$
- d. No contact angle
- e. A contact angle $= 180^\circ$

[2 points]

32. True or false: Holding a pipette completely vertically results in bigger droplets.

[2 points]

[End of Questions]

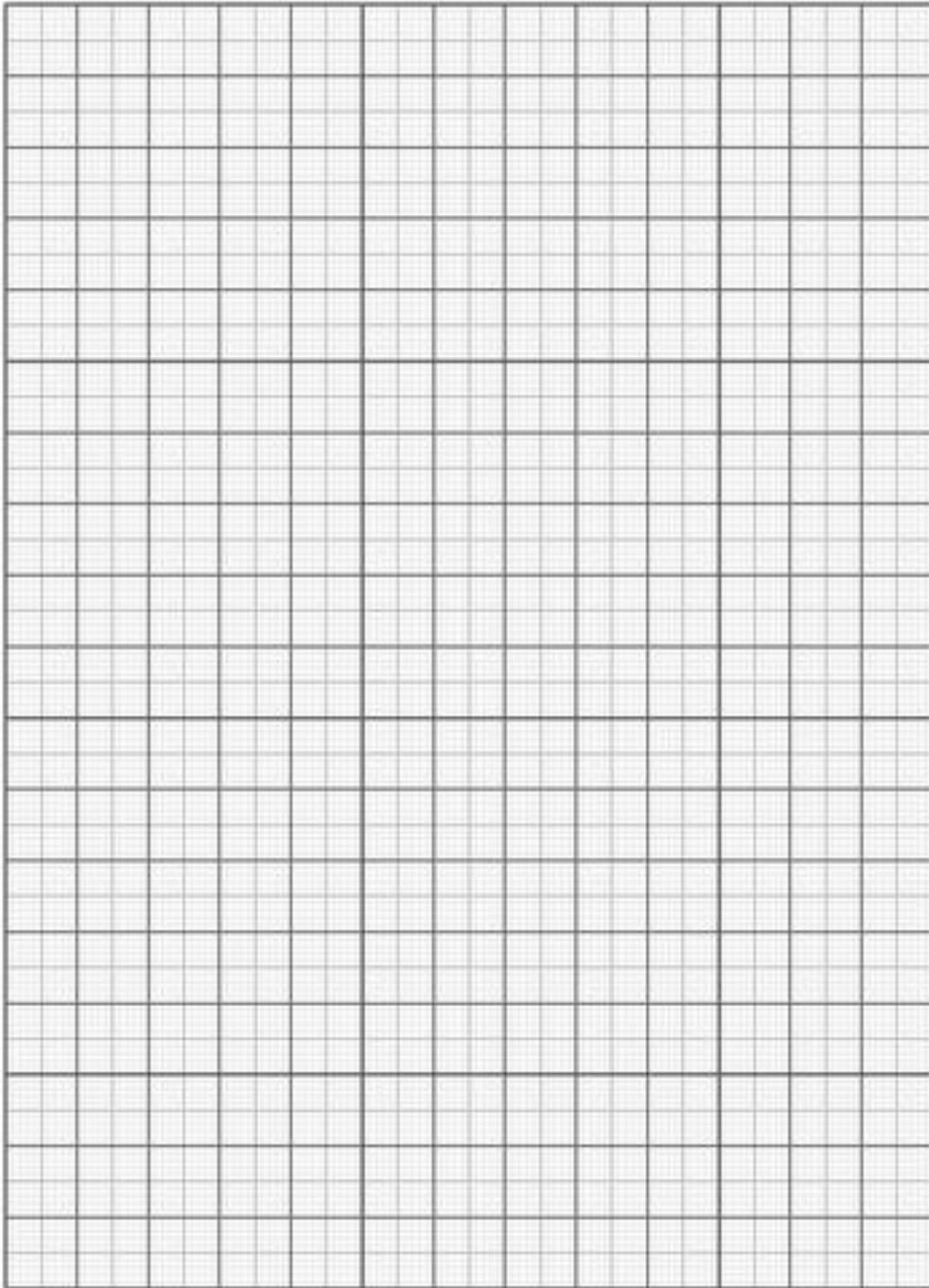
Materials Science Answer Sheet

Team Name: _____ Team Number: _____

1.

Mass	Stress	Strain

2.



Young's Modulus: _____

3.

	Unknown #1	Unknown #2	Unknown #3
Times/ Observation			

4.

Unknown #1	Unknown #2	Unknown #3

Reasoning:

Team Name: _____ **Team #:** _____

5. _____

6. _____ 8. _____ 9. _____

10. _____

11. _____

12. _____

13. _____

14. _____

15. _____

16. _____

17. _____ 18. _____ 19. _____ 20. _____ 21. _____

22. _____ 23. _____ 24. _____ 25. _____ 26. _____

27.

Answer: _____

28.

Answer: _____

29. _____

30.

Answer: _____

31. _____

32. _____

33. _____