Material Science - key

RAHS C Division Invitational 2017-18

Instructions:

- Answer all questions on this answer sheet.
- Sheets may be double sided, check both sides!
- If you separate the sheets of the test be sure to label each sheet with school/team and ID in case they get mixed up during scoring.
- Tie breakers:

For Scoring only

Test score **(Your Points/ 133** **=_____**

Rank **/24** **=_____**

Multiple Choice (2 pts each)

1. Buna-S is also known as
   a. PTFE
   b. Teflon
   c. Polycrylates
   d. Styrene butadiene rubber (SBR)

2. Neoprene is chemically known as
   a. Styrene butadiene rubber (SBR)
   b. Polyurethane
   c. Polybutandiene
   d. Poly chloroprene

3. Buna-S is a _____ material
   a. Resinous
   b. Rubbery
   c. Fibrous
   d. Plastic

4. Automobile steering wheels are normally made of
   a. Cellulose acetate
   b. PVC
   c. High density polythene
   d. Cellulose nitrate

5. Polymethyl methacrylate (PMMA) is known as
   a. Perspex
   b. Teflon
   c. Bakelite
   d. Nylon-6

6. Mastication of rubber means
   a. Its softening
   b. A treatment to retard its deterioration due to oxidation
   c. Improving its curing rate
   d. Depression of its freezing point

7. Cellulose is the main constituent of moist _____fibers
   a. acrylic
   b. synthetic
   c. Spandex
   d. Natural

8. Reaction of dimethyl terephthalate (DMT) and ethylene glycol produces

a. Nylon-6
b. Polyester
c. Dacron
d. PVC

9. In a cross-linked polymer, the monomeric units are linked together to constitute a three-dimensional network. Which of the following is a cross-linked polymer?

a. Bakelite (phenol formaldehyde)
b. Polythene
c. Nylon-6
d. Polyester

10. Out of all the elastomers, natural rubber has the longest elongate range and flexibility of the order of _____ percent.

a. 1-1000
b. 1500-2000
c. 1000-1500
d. 2000-2500

11. The monomer of poly vinyl chloride (PVC) is

a. Ethyl chloride
b. Chloroform
c. Ethylene dichloride
d. Chloroethane

12. Neoprene is a

a. Synthetic rubber
b. Monomer
c. Polyester
d. None of these

13. These tubes are a good substitute for human blood vessels on heart by-pass operations

a. PVC
b. Polythene
c. Teflon/Dacron
d. Polystyrene

14. The main use of butadiene is

a. As an anti-skimming agent in paint
b. In the manufacture of synthetic rubber
c. As a plasticizer for unsaturated polyester
d. None of these

15. Which of the following polymer type is not classified on the basis of its application and properties?

a. Rubber
b. Plastic
c. Fiber
d. Synthetic

16. Which of the following is a thermosetting polymer?
    a. Polystyrene
    b. Polyolefins
    c. Nylons
    d. Resins
17. Where is polyurethane foam used extensively?
    a. Adhesive
    b. Paint rollers
    c. Printing rollers
    d. Fabric coating
18. What is the use of epoxy resin from a commercial point of view?
    a. As strength adhesives
    b. As cementing agents
    c. Cast objects and laminates
    d. All of the above
19. What is the common or brand name of the polymer polyacrylonitrile?
    a. Mylar
    b. Orlon
    c. Technora
    d. Ultem
20. Most polymers have a specific heat of approximately
    a. 0.004 calories/gram
    b. 0.4 calories/gram
    c. 400 calories/gram
    d. None of the above. The specific heat of polymers is extremely varied

21. Fill in the table using the information below (1 point per box on table)

Code	Description (abbreviation)	Packaging Applications (list two)	Recycled Products (list two)
			
			
			
			
			
			

Descriptions:	Packaging Applications *	Recycled Products*
High Density Polyethylene (HDPE) Low Density Polyethylene (LDPE) Polyethylene Terephthalate (PET, PETE) Polypropylene (PP) Polystyrene (PS) Vinyl (Polyvinyl Chloride or PVC)	Bread and frozen food bags Catsup Bottles Cereal box liners Compact disc jackets Dry Cleaning Egg cartons House siding Medical Tubing Medicine Bottles Milk bottles Ovenable film/food trays Peanut butter jars Plastic Cutlery Plastic soft drink bottles Squeezable bottles (i.e. honey) Wire and cable insulation Yogurt and margarine tubs	Battery cables Bottles Buckets Cables Carpet Egg cartons Fleece clothing Floor tiles Foam packing Furniture Garbage can liners Ice scrapers Loose leaf binders Luggage Pallets Plastic lumber Shampoo bottles Shipping envelopes Thermometers Traffic Cones Trash cans
Note: Some of these may apply to more than one recycle code.		

Codes	Descriptions	Properties	Packaging Applications	Recycled Products
	Polyethylene Terephthalate (PET, PETE). PET is clear, tough, and has good gas and moisture barrier properties. Commonly used in soft drink bottles and many injection molded consumer product containers. Other applications include strapping and both food and non-food containers. Cleaned, recycled PET flakes and pellets are in great demand for spinning fiber for carpet yarns, producing fiberfill and geo-textiles. Nickname: Polyester.	Clarity, strength, toughness, barrier to gas and moisture, resistance to heat	Plastic soft drink, water, sports drink, beer, mouthwash, catsup and salad dressing bottles. Peanut butter, pickle, jelly and jam jars. Ovenable film and ovenable prepared food trays.	Fiber, tote bags, clothing, film and sheet, food and beverage containers, carpet, strapping, fleece wear, luggage and bottles.
	High Density Polyethylene (HDPE). HDPE is used to make bottles for milk, juice, water and laundry products. Unpigmented bottles are translucent, have good barrier properties and stiffness, and are well suited to packaging products with a short shelf life such as milk. Because HDPE has good chemical resistance, it is used for packaging many household and industrial chemicals such as detergents and bleach. Pigmented HDPE bottles have better stress crack resistance than unpigmented HDPE bottles.	Stiffness, strength, toughness, resistance to chemicals and moisture, permeability to gas, ease of processing, and ease of forming.	Milk, water, juice, cosmetic, shampoo, dish and laundry detergent bottles; yogurt and margarine tubs; cereal box liners; grocery, trash and retail bags.	Liquid laundry detergent, shampoo, conditioner and motor oil bottles; pipe, buckets, crates, flower pots, garden edging, film and sheet, recycling bins, benches, dog houses, plastic lumber, floor tiles, picnic tables, fencing.
	Vinyl (Polyvinyl Chloride or PVC): In addition to its stable physical properties, PVC has excellent chemical resistance, good weatherability, flow characteristics and stable electrical properties. The diverse slate of vinyl products can be broadly divided into rigid and flexible materials. Bottles and packaging sheet are major rigid markets, but it is also widely used in the construction market for such applications as pipes and fittings, siding, carpet backing and windows. Flexible vinyl is used in wire and cable insulation, film and sheet, floor coverings synthetic leather products, coatings, blood bags, medical tubing and many other applications.	Versatility, clarity, ease of blending, strength, toughness, resistance to grease, oil and chemicals.	Clear food and non-food packaging, medical tubing, wire and cable insulation, film and sheet, construction products such as pipes, fittings, siding, floor tiles, carpet backing and window frames..	Packaging, loose-leaf binders, decking, paneling, gutters, mud flaps, film and sheet, floor tiles and mats, resilient flooring, cassette trays, electrical boxes, cables, traffic cones, garden hose, mobile home skirting.
	Low Density Polyethylene(LDPE).Used predominately in film applications due to its toughness, flexibility and relative transparency, making it popular for use in applications where heat sealing is necessary. LDPE is also used to manufacture some flexible lids and bottles and it is used in wire and cable applications	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Dry cleaning, bread and frozen food bags, squeezable bottles, e.g. honey, mustard.	Shipping envelopes, garbage can liners, floor tile, furniture, film and sheet, compost bins, paneling, trash cans, landscape timber, lumber
	Polypropylene (PP). Polypropylene has good chemical resistance, is strong, and has a high melting point making it good for hot-fill liquids. PP is found in flexible and rigid packaging to fibers and large molded parts for automotive and consumer products.	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture.	Catsup bottles, yogurt containers and margarine tubs, medicine bottles	Automobile battery cases, signal lights, battery cables, brooms, brushes, ice scrapers, oil funnels, bicycle racks, rakes, bins, pallets, sheeting, trays.
	Polystyrene (PS). Polystyrene is a versatile plastic that can be rigid or foamed. General purpose polystyrene is clear, hard and brittle. It has a relatively low melting point. Typical applications include protective packaging, containers, lids, cups, bottles and trays.	Versatility, insulation, clarity, easily formed	Compact disc jackets, food service applications, grocery store meat trays, egg cartons, aspirin bottles, cups, plates, cutlery.	Thermometers, light switch plates, thermal insulation, egg cartons, vents, desk trays, rulers, license plate frames, foam packing, foam plates, cups, utensils

22. (3 pts) How can chemists control which type of polyethylene (LDPE vs HDPE) is generated?

Answer: Through the choice of appropriate catalysts and reaction conditions.

23. (3 pts) How does the molecular-level structure of polyethylene (LDPE and HDPE) influence their material properties?

Answer: The structure (e.g. extent of branching) determines how the individual polymer molecules can orient (or "pack") in the solid state. This, in turn, influences physical properties such as density.

24. (3 pts) Define thermoplastics.

Answer: Polymers that can be melted and reshaped through the application of heat and pressure. Thermoplastics can also be softened by heat and hardened by cooling in a reversible process.

25. (3 pts) Define thermosets.

Answer: Polymers that decompose before they can be melted or reshaped. They are crosslinked and cannot be softened by heating.

26. (3 pts) Can thermoplastics polymers be transformed to thermosetting polymers? If so, how?

Answer: Yes, thermoplastics can be transformed to thermosetting polymers by the introduction of crosslinks between the polymer chains.

27. (1 pt) Can thermoplastics be recycled? **Yes** No

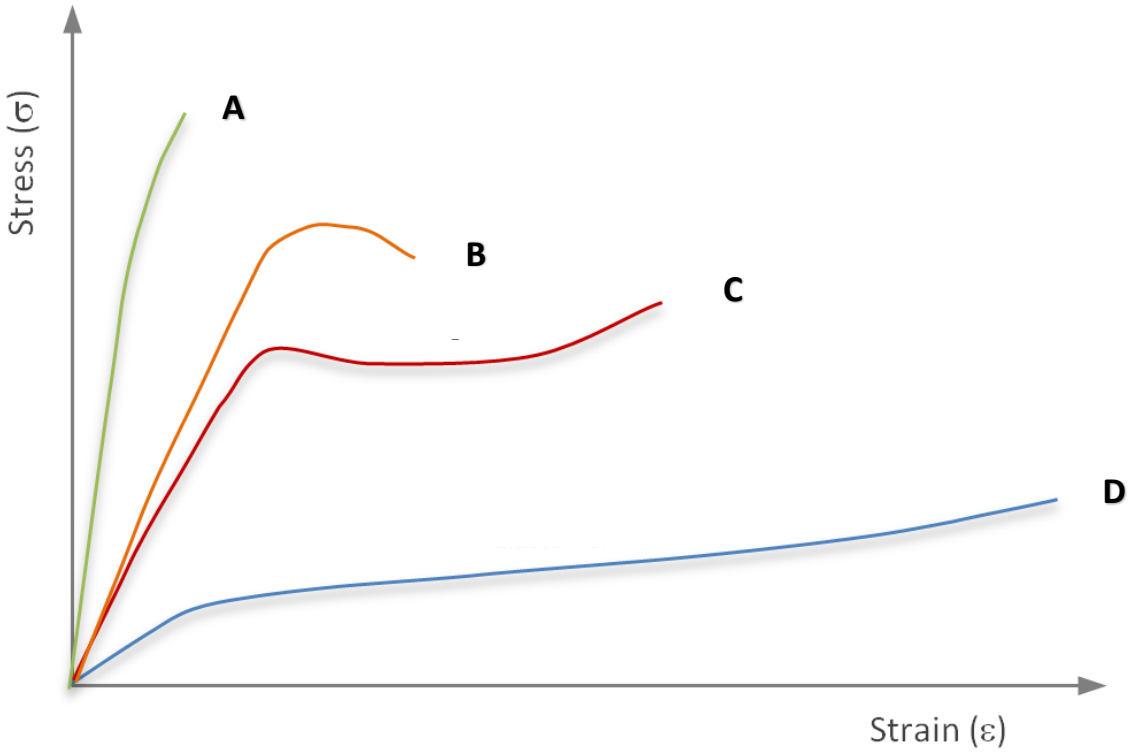
28. (1 pt) Can thermosets be recycled? **Yes** No

29. (1 pt) Is it easier to recycle thermoplastics or thermosets? **Thermoplastics**

30. Indicate whether the following polymers are thermoset, thermoplastic or neither. (1 pt each)

Item	Thermoset	Thermoplastic	Neither
Cellulose		X	
Unvulcanized rubber		X	
A-stage resole	X		
Cellulose Nitrate		X	
Molded Bakelite	X		
Ebonite	X		
Meat			X

Stress-Strain Behavior of Polymers



31. (2 pts) Which polymer is the most brittle?

(A) B C D

32. (2 pts) Which polymer is most ductile?

A B C (D)

33. (2 pts) Which polymer is strong and tough?

A (B) C D

34. (2 pts) Which polymer is hard and tough (with possible strain hardening)?

A B (C) D

35. (2 pts) Which polymer has the greatest Modulus of Elasticity?

(A) B C D

For questions 36 and 37 use the following values:

Poly(ethyl acrylate) PEA has a Specific Heat Capacity of at approximately 1.7867 kJ/kg/C for a given temperature.

36. (4 pts) A 5.00 kg block of PEA is heated, increasing its temperature by 2.50 °C. How much energy has been added to the block?

$Q = m \times c_p \times (T_2 - T_1) = (5.00\ kg)(1.7867\ kJ/kg/C)(2.50\ C) = 22.3\ kJ$

37. (4 pts) A 3.00 kg block of PEA is cooled, reducing its energy by 42.00 kJ. What is the temperature change or the PEA?

$Q = m \times c_p \times (T_2 - T_1)$

$(T_2 - T_1) = Q/m/c_p = 42.00\ kJ/3.00\ kg/(1.7867\ kJ/kg/C) = 7.84\ C$

38 (4 pts) A block of PEA is heated, increasing its energy by 15.00 kJ. The temperature of the block is raised 7.00°C. What is the mass of the block?

$m = Q/(T_2 - T_1)/c_p = 15.00\ kJ/7.00\ C/(1.7867\ kJ/kg/C) = 1.20\ kg$

For questions 39 and 40 use the following values:

Shear Modulus: G = 1.25 GPA

Young's Modulus: E = 3.5 GPa

39. (4 pts) What is the strain of a rod that has a diameter of 20 mm^2 if a load of 5,000 kN is applied to the rod?

Strain = E/stress = EA/P = (3.5 GPA)*(20 mm^2)/5000 kN

= (3.5E9)(20E-6)/(5000E3) = 0.014 (mm/mm or dimensionless)

40. (4 pts) Calculate Poisson's Ratio.

$$G=E/2(1+v)$$

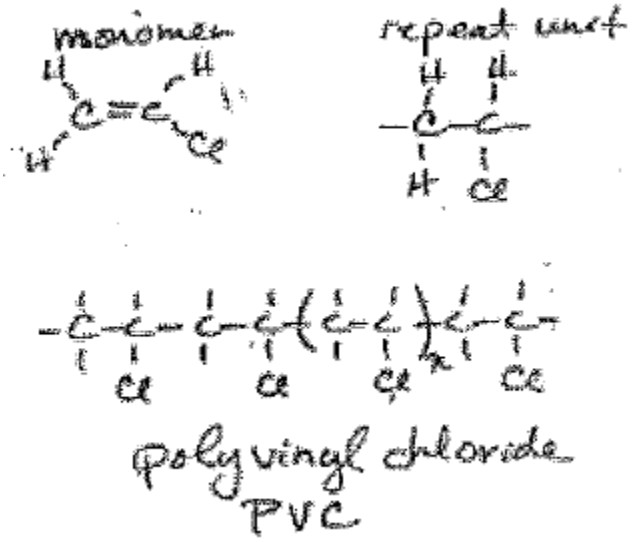
$2(1+v) = E/2G - 1 = (3.5\ GPa/2/1.25\ GPa) - 1 = 0.4$ (dimensionless)

Note: take off one point if sig figs are not correct and one point if units are missing or incorrect.

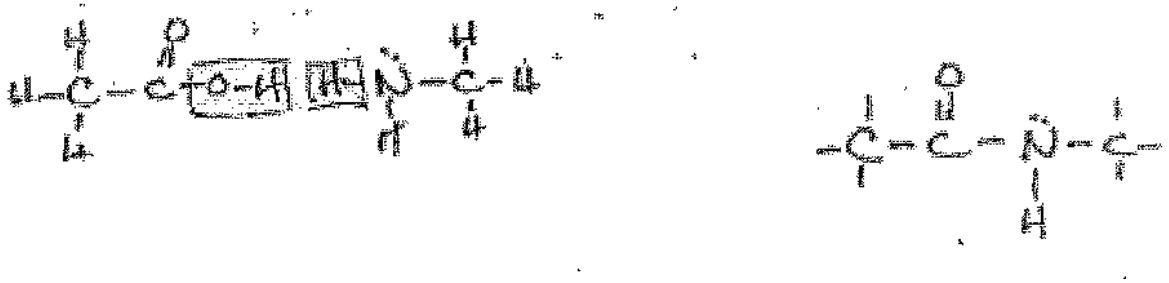
Drawings

41. (5 pts) Draw and label the three isomers of dibromebenzene use ortho, para, meta, nomenclature.

42. (5 pts) Draw the polymer formed from the monomer vinyl chloride, CH_2CHCL:



43. (5 pts) Draw CH_3COOH and CH_3NH_2. Draw the condensation product of the reaction.



44. (5 pts) Polyesters (a condensation polymer) can be formed from two different monomers, a di-acid and a di-alcohol. Draw the two monomers and draw a polymer made of three of each unit.

$HOOCC_6H_4COOH$ benzene ring with two acid groups in para positions	$HOCH_2CH_2OH$ ethane with an –OH group on each carbon