



DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY
GEOHERMAL ENERGY TRAINING AND RESEARCH INSTITUTE
MSc IN GEOHERMAL ENERGY TECHNOLOGY

SPECIAL EXAMINATIONS

GET 4001: HEAT AND MASS TRANSFER

DATE:

TIME: 3 HOURS

INSTRUCTIONS

- 1) TIME ALLOCATED – 3 hours
 - 2) There are FIVE QUESTIONS in this paper
 - 3) Attempt only THREE questions
 - 4) Question 1 is compulsory and is worth 30 marks. The other two are 15 marks each
 - 5) This Paper will count for 60% of the total score of GET 4001. The other 40% will be earned from CATS and assignments
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Question 1 [30 marks] – This question is Compulsory

(a) Discuss TWO main modes that heat can be transferred within geothermal systems. (5 Marks)

(b) Write an equation describing the rate of heat conduction through a plane layer and define the terms you use. (5 Marks)

(c) Define the term *Thermal Gradient* and give its SI units. (5 Marks)

(d) Heat transfer by Convection can be given as

$$q = h A \ t$$

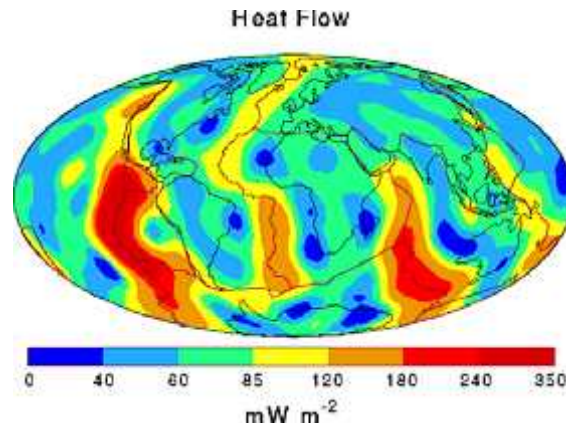
Define the terms in the equation. (5 Marks)

(e) A planar wall has a temperature of 800^o C on one side and 50^o C on the other side. If the wall is 10 cm thick, and has a thermal conductance of 0.5 W/(mK), how much heat is transmitted through the wall per unit area (per m²)? (5 Marks)

(f) Most rocks are saturated with water below the water table, which occurs generally at depths shallower than 100 m. Geothermal fluids occur at greater depths than this. These rocks are also composed of various minerals. Discuss how heat transfer is affected by presence of fluids, fluid permeability, rock type and pore geometry. (5 marks)

Question 2 [15 marks] – This question is Optional

(a) The figure below is a global heat flow map.



Offer an explanation as to why heat flux is high / concentrated in some regions of the earth. (5 Marks)

(b) How does a conventional geothermal reservoir work? How does it get its heat? (5 Marks)

(c) Discuss the concept behind the Hot Dry Rock Geothermal Energy program (Engineered or Enhanced Geothermal Systems (EGS)). How successful has it been? Why / how and what are the limitations? (5 Marks)

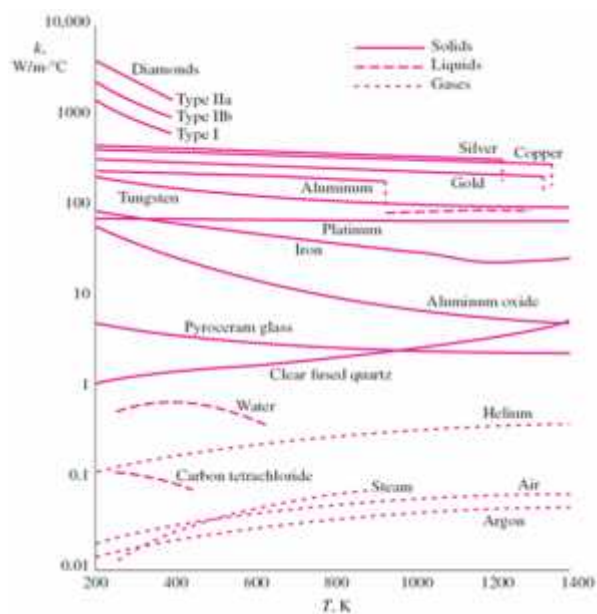
Question 3 [15 marks] – This question is Optional

(a) Given a core sample from a geothermal well, briefly describe how you can measure its thermal conductivity. (10 Marks)

(b) Discuss how Geothermal Heat Pump can efficiently heat or cool air in homes and buildings. (5 Marks)

Question 4 [15 marks] – This question is Optional

(a) Using the figure and table below discuss thermal conductivity scenarios on various substances. That is, offer explanations why some materials (giving examples) are better heat conductors than others (10 Marks)



Thermal conductivities of materials vary with temperature

T, K	k, W/m·K	
	Copper	Aluminum
100	482	302
200	413	237
300	401	237
400	393	240
600	379	231
800	366	218

The variation of the thermal conductivity of various solids, liquids, and gases with temperature.

(b) Discuss the difference between Conduction Heat Transfer and Convection Heat Transfer. Which mode is dominant in geothermal systems? (5 Marks)

Question 5 [15 marks] – This question is Optional

(a) A geothermal exploration well was drilled into a region with several magma chambers in the vicinity. However, it was found not to be as hot as expected, just lukewarm. Offer possible explanations for this scenario. [10 marks]

(b) Offer any similarities and/or any differences between the mechanisms for the transport of heat and electricity in rocks. In your discourse, do not forget to talk about Archie's Law. (5 Marks)