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DEVELOPMENT AND VALIDATION OF HEAT ENERGY ACHIEVEMENT TEST FOR SENIOR SECONDARY TWO STUDENTS IN PHYSICS IN JOS METROPOLIS, NIGERIA

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ABSTRACT: *This study was undertaken to develop and validate heat energy achievement test (HEAT) for senior secondary two students in Jos metropolis, Nigeria. The heat energy achievement test is an instrument for determining the achievement of students in Physics from the senior secondary two Physics curriculum. The inappropriate use of relevant teaching strategies which are not student-centred and poorly developed test instruments by classroom teachers may result in lack of better understanding of Physics concepts by students and hence, the poor achievement of students in Physics. This study was, therefore, carried out to assist teachers to be more effective in constructing achievement tests in Physics. The HEAT was developed, validated, and was found to be reliable (coefficient of reliability = 0.83) for use as a test instrument. It was further administered to students offering Physics. Recommendations were made which include Postgraduate students of Physics Education and related courses should adopt or adapt HEAT, instead of developing, when carrying out research involving heat energy measurements.*

KEYWORDS: Development, Heat Energy Achievement Test, Jos Metropolis, Nigeria, Physics, Senior Secondary Two, Validation.

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INTRODUCTION

Physics is a science subject that provides the relationship between inanimate matter and energy, which forms a basis of technologically-enhanced human livelihood. The Nigerian Educational Research and Development Council [NERDC], (2008) opined that the knowledge of Physics is critical for effective living in the contemporary science and technology world. This is an indication that the study of Physics at the secondary school level, which is where the basics of Physics are taught, should not be underestimated. Physics is useful to man in all facets of life through its principles, laws and theories. For instance, it is in the electric light that is switched on, the car that is driven, the wrist-watch that is strapped on, the cell phone, radio and television set. It is in the equipment used for diagnosing diseases in patients, be it out-patients or in-patients. It is also in the football that is being played or watched. It then means that a decline in the comprehension of Physics concepts which underpins the understanding of other fields will result to a gradual decline in the understanding of such fields as agriculture, engineering, medicine, telecommunication and pharmacy.

Despite the importance of Physics to national development, the situation of students' achievement in Physics examinations in Nigeria such as Senior School Certificate Examination (SSCE) organized by National Examinations Council (NECO) and West Africa Secondary Schools Certificate Examinations Council (WASSE) organized by the West African Examination Council (WAEC) and has been unsatisfactory and fluctuates over the years. Chief examiners' reports indicate that in such examinations students could not provide correct explanations of evaporation, working principle of refrigerator, and conversion of heat energy to mechanical energy. They could hardly state correctly four factors which affect the rate of evaporation and could hardly understand basic concepts such as boiling point of liquids and principles of Physics in heat energy. Furthermore, the chief examiners pointed out that many students could hardly go beyond reproduction of the basic formula for linear expansivity, and were unable to interpret statements into workable diagrams; students exhibited poor manipulation of arithmetic processes, and were unable to relate the principle of latent heat of vaporization to the preservation of tomatoes in most jute bags. Furthermore, the reports showed that students defined specific heat capacity instead, when they were asked to define heat capacity (NECO, 2009-2012; WAEC, 2015, 2017).

The situation of students' achievement in Physics in Jos Metropolis was not too impressive and fluctuated in the June/July NECO SSCE and May/June WASSE Physics examination from 2006 to 2018 and 2007 to 2018, respectively. The achievement of students in the NECO SSCE Physics examination in Jos Metropolis, Nigeria from 2010 to 2018, indicated that in 2010 to 2012, a very poor achievement was recorded in Physics. Only 710 students representing 27.28%, 393 students representing 15.94% and 321 students representing 41.69% in 2010, 2011 and 2012 respectively passed Physics at credit level and above. Even though the achievement at credit level and above in the years 2013-2018 under review was high and increased by the years, a decrease of 2.88% (85.72-88.60) was obtained when the result of 2017 is compared with that of 2016. Moreover, 23.39% (on the average) of the total population that sat for the Physics examination in the nine years under consideration (2010-2018) failed to secure at least a credit in Physics. This is also worrisome as such students could not have been afforded the opportunity to study Physics and Physics-related courses in higher institutions of learning. A more worrisome question is 'What befell the 72.72%, 84.06% and 58.31% of the students that failed to obtain credit and above in the examination in 2010 to 2012?' Such

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students might have wished to study Physics or Physics-related courses in higher institutions of learning.

A cursory view of the statistics of WASSEC Physics results in Jos metropolis also showed an unimpressive and fluctuating trend in the percentage pass of the students in the years 2012-2018. Although there was an impressive 78.84% pass at credit level and above in the year 2016, an average percentage fail in achievement of 44.56% in the seven years under review leaves much to be desired. These fluctuations or poor achievement of students in Physics may be attributed to many factors which include ineffective methods of teaching Physics employed by teachers in the classroom, the lack of motivation which such methods present to the students, and dearth of qualified and experienced Physics teachers in secondary schools. Chief examiner's reports on Physics examinations by National Examinations Council (2009-2012) and West Africa Examinations Council (2016) also indicated that students lack understanding of concepts in heat energy measurements. The unimpressive and fluctuating achievement may be due to poorly developed test instruments by Physics teachers which are also not validated, but used in the classroom; thereby not adequately preparing students for achievement in external examinations. There is the need, therefore, to prepare Physics teachers towards developing and validating test instruments which may consequently enhance their students' achievement.

Statement of the Problem

The persistent fluctuations and not too impressive achievement in the Physics examinations has been a source of concern. This situation has been attributed to ineffective methods of teaching Physics, such as the conventional lecture method, employed by teachers in the classroom (Josiah, 2020) and Physics teachers' inability to develop and validate test instruments, among others. The consequences of allowing the problem to persist cannot be under-estimated: There may be a gradual and subsequent decline in the enrolment of students to study Physics and Physics-related fields in tertiary institutions of higher learning, which will lead to decline or dearth in technology manpower required for developing the nation. This implies that technological advances that drive the economic engines of the nation will gradually collapse. Consequently, the quality of life of the people will deteriorate. The problem, therefore, will be to develop heat energy achievement test for senior secondary two students in Jos metropolis, Nigeria, validate the instrument and find its reliability and efficacy on achievement of students in senior secondary two heat energy concepts.

Purpose of the Study

The purpose of the study was to develop and validate heat energy achievement test for senior secondary two students in Physics in Jos metropolis, Nigeria. The specific objectives of the study were to:

1. develop heat energy achievement test (HEAT) for senior secondary two (SS II) students in Physics in Jos metropolis, Nigeria
2. validate the HEAT for SS II students in Physics.
3. determine the reliability of the HEAT for SS II students in Physics.
4. test the HEAT for SS II students in Physics.

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Research Questions

The following research questions were raised and answered:

1. What are the steps in developing the HEAT for SS II students in Physics?
2. What is the validation process of the HEAT for SS II students in Physics?
3. What is the reliability coefficient of the HEAT for SS II students in Physics?
4. What are the mean achievement scores of SS II students in the HEAT in Physics?

METHODOLOGY

The study adopted the non-equivalent control group pre-test, post-test quasi-experimental research design because intact classes were used. The table of Random Digits of the simple random sampling technique was used to sample four co-educational secondary schools for the study. This was because school type (public and private) was considered as strata. One each of the two public and private schools were randomly assigned the experimental groups while the second were assigned to the control groups. A total intact sample of 128 SS II students (66 male and 62 female) offering Physics from the four sampled co-educational secondary schools in Bukuru Metropolis was used to gather data for the pilot study. The study was carried out using SS II students because the concepts of heat energy measurements is in the SS II senior secondary school Physics curriculum (in use in most schools) as provided by Nigerian Educational Research and Development Council (2008).

The HEAT (Appendix 1), which was a 50-item multiple-choice instrument, was developed, validated, subjected to reliability test and administered as pre-test to all the sample in the two groups by the researcher, before treatment on the experimental group. A total intact sample of 145 SS II students (78 male and 67 female) offering Physics from the four sampled co-educational secondary schools in Jos Metropolis was used to gather data for the main study. The instrument was administered a week before the treatment commenced. The pre-test was carried out so as to determine the entry ability of the sample students in the concepts of heat energy measurements. Thereafter, treatment was carried out on the experimental group for a period of four weeks on the concepts of heat energy measurements. The control group was merely engaged on the same concepts of heat energy measurements by being taught using the conventional lecture method during the same period of four weeks that the experimental group was treated. After the four weeks treatment, in the fifth week, the HEAT was re-administered as post-test to all the students in both the experimental and control groups, after reshuffling the items. The mean, a descriptive statistics, was used to answer research question four.

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RESULTS/FINDINGS

Research Question One

What are the steps in developing the HEAT for SS II students in Physics?

Heat Energy Achievement Test (HEAT) was developed using a table of specification and was based on WASSCE and NECO SSCE syllabi on the concepts of heat energy measurement; in conjunction with the behavioural objectives of the lesson plans for both experimental and control groups. The use of the table of specification in developing HEAT is more appropriate as it specifies the content and relevant objectives (based on Bloom's Taxonomy) to be covered by a test. Commenting on the importance of a table of specification, Alade and Omoruyi (2014) were of the opinion that the table aids teachers to align behavioural objectives of a lesson, method/strategy used in teaching the lesson and assessment of the teaching. Table 1 provides the table of specification for construction of the Heat Energy Achievement Test.

Table 1: Table of Specifications for the Construction of Heat Energy Achievement Test (HEAT) for Senior Secondary Two Students

Content Area	Total Time Spent on Topic (Mins)	Cognitive Objectives						
		Knowledge 42%	Comprehension 36%	Application 10%	Analysis 8%	Synthesis 4%	Evaluation	Total 100 %
Specific heat capacity	120	6 (11, 15, 18, 21, 27, 50)	5 (9, 12, 22, 28, 49)	2 (10, 19)	1 (26)	1 (30)	-	15
Specific latent heat	120	6 (2, 7, 14, 24, 34, 44)	5 (1, 8, 25, 29, 45)	2 (20, 43)	1 (31)	1 (3)	-	15
Effect of pressure and impurities on melting and boiling points	80	4 (16, 17, 39, 48)	4 (23, 32,40, 41)	1(38)	1 (36)	-	-	10
Evaporation, boiling and sublimation	40	2 (13, 37)	2 (42, 47)	1(6)	-	-	-	5
Relative humidity and dew point	40	2 (4, 5)	2 (35, 46)	1(33)	-	-		5
Total	400	21	18	5	4	2	-	50

Note: Numbers outside the brackets signify Number of questions per content area per cognitive domain; Numbers inside the brackets signify Item number in HEAT instrument

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The items in Table 1 for HEAT were developed using the following steps:

1. Identifying the topics and behavioural objectives which will be covered under heat energy measurements in SS II Physics curriculum during teaching.
2. Arranging the concepts of heat energy measurements from simple to complex.
3. Finding out the number of items that will make up the HEAT.
4. Assigning items to each topic on heat energy measurements (as contained in SS II Physics curriculum) based on the behavioural objectives and teaching period allotted to them.
5. Producing the HEAT items.
6. Subjecting the items in HEAT to expert judgement.
7. Editing the items on HEAT, based on expert judgement.
8. Producing the final copy of HEAT.
9. Preparing model answers for HEAT.

In order to produce the items on the test instrument (step 5 above), percentages were first assigned to Bloom's cognitive domain objectives that were used in developing the test instrument. Knowledge, comprehension, application, analysis and synthesis were assigned the following respective percentages (obtained from the behavioural objectives of the lesson plans): 42%, 36%, 10%, 8% and 4%. The next step was to list out the SS II content of heat energy measurements that was covered in the study, the total time that was spent on each content area and the percentage of the total items each of the content areas will have. The content areas of heat energy measurements and the total time spent on each content area are as follows: Specific heat capacity (120 minutes), Specific latent heat (120 minutes), Effect of pressure and impurities on melting and boiling points (80 minutes), Evaporation, boiling and sublimation (40 minutes) and, Relative humidity and dew point (40 minutes). The content areas of heat energy measurements and the percentage of the total items each of the content areas will have are as follows: Specific heat capacity (30%), Specific latent heat (30%), Effect of pressure and impurities on melting and boiling points (20%), Evaporation, boiling and sublimation (10%) and, Relative humidity and dew point (10%).

The next step was for the researcher to arrange the objectives, their percentages, the content areas and the total time to be spent on each content area in tabular form as indicated in Table 1. The researcher then took a decision on the total number of items Heat Energy Achievement Test would have. The total number of items the test instrument had is 50. The researcher then determined the total items for each of the specified content area in relation to the cognitive domain objectives used for the study. This implies that the totals of objectives in the cognitive domain for both the horizontal and vertical rows in Table 3 were obtained. For the horizontal row, Abonyi (2011) opined that the total items for each of the specified content area in relation to the cognitive domain objectives is obtained by multiplying the percentage of the total items each of the content areas will have with the total number of items the instrument will have. Therefore, Specific heat capacity had 30% of 50 items (15 items), Specific latent heat had 30% of 50 items (15 items), Effect of pressure and impurities on melting and boiling points had 20% of 50 items (10 items), Evaporation, boiling and sublimation had 10% of 50 items (5 items)

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and, Relative humidity and dew point had 10% of 50 items (5 items). These percentages represent the total time spent on teaching each topic during treatment.

The next step was to determine the actual number of questions to be set representing each content area per cognitive domain (objective level). Ugodulunwa (2008) was of the view that the number of questions to be set per content area per cognitive domain is equal to the product of the weight of content area, weight of objective level and total number of questions in the test instrument. Therefore, in knowledge as an objective level Specific heat capacity and Specific latent heat had 6 items each, Effect of pressure and impurities on melting and boiling points had 4 items, Evaporation, boiling and sublimation; and, Relative humidity and dew point had 2 items each. In comprehension as an objective level, Specific heat capacity and Specific latent heat had 5 items each, Effect of pressure and impurities on melting and boiling points had 4 items, Evaporation, boiling and sublimation; and, Relative humidity and dew point had 2 items each. In application as an objective level, Specific heat capacity and Specific latent heat had 2 items each, Effect of pressure and impurities on melting and boiling points; Evaporation, boiling and sublimation; and, Relative humidity and dew point had 1 item each. In analysis as an objective level, Specific heat capacity; Specific latent heat; and Effect of pressure and impurities on melting and boiling points had 1 item each. Evaporation, boiling and sublimation; and, Relative humidity and dew point had no item. In synthesis as an objective level, Specific heat capacity and Specific latent heat had 1 item each. Effect of pressure and impurities on melting and boiling points; Evaporation, boiling and sublimation; and, Relative humidity and dew point had no item.

Research Question Two

What is the validation process of the HEAT for SS II students in Physics?

Face and content validity of Heat Energy Achievement Test (HEAT) were done by three experts, one from Physics Education Unit, Faculty of Education in University of Jos, the second from Test and Measurement Unit of the Faculty of Education, University of Jos and the third a seasoned Physics teacher from a secondary school in Jos South Local Government Area of Plateau state, Nigeria. All the experts adjudged the instrument as being of good quality, comprehensive, adequate, relevant and suitable for the study.

The validation was done so as to ensure the adequacy and comprehensiveness of the items in the two instruments as well as to clarify expressions used in the instruments. Based on the experts' comments on the instruments, necessary corrections and modifications were effected. A copy of the HEAT was given to each of the mentioned experts for the validation alongside the objectives of the study, research questions and hypotheses.

Research Question Three

What is the reliability coefficient of the HEAT for SS II students in Physics?

To ascertain the reliability of the HEAT, a pilot test was carried out in co-educational secondary schools in Bukuru Metropolis of Jos-South Local Government Area of Plateau State, Nigeria. The choice of those schools for pilot-testing of the instruments was because they did not fall in the area where the main study was to be conducted. Moreover, the schools had the same characteristics in terms of learning environment and quality of Physics teachers as the schools that were to be used for the main study.

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After collecting data from the pilot study, the reliability coefficient of HEAT was obtained as 0.83 using Kuder-Richardson formula 20 (K-R 20) on the Statistical Package for Social Sciences (SPSS) Software Version 25. This formula was used because it measures internal consistency of test instruments and is applicable to tests that are scored dichotomously (one point for each correct option and zero point for each wrong option). The HEAT is reliable since, according to Fraenkel and Wallen as cited in Awotunde and Ugodulunwa (2004), a reliability coefficient of at least 0.70 is acceptable for an instrument to be reliable.

Research Question Four

What are the mean a scores of SS II students in the HEAT in Physics?

The summary of the pre-test and post-test mean achievement scores of SS II students in the HEAT in Physics is presented in Table 2. It presents the summary of the data analysis on research question three.

Table 2: Pre-test and Post-test Mean Achievement Scores of SS II Students in the HEAT in Physics

School		Pre-test		Post-test	
	N	□	SD	□	SD
A	82	35.98	7.35	68.05	6.06
B	63	36.34	8.30	37.91	10.61

The findings in Table 2 reveal respective pre-test and post-test mean achievement scores of 35.98 and 68.05 for students in school A; while those in school B had respective pre-test and post-test mean achievement scores of 36.34 and 37.91. This finding reveals that not much difference was observed in the pre-test mean achievement scores of students in the two schools. The result, however, further indicated that students in school A had a higher post-test mean achievement score (68.05) than those in school B (37.91). The difference in the post-test mean achievement scores of students in the two schools could be attributed to the different methods of instruction used in teaching the students in the two schools. While students in school A were taught using Jigsaw IV cooperative strategy, those in school B were taught using the conventional lecture method. This implies that the different instructional methods used in the teaching could have resulted to the varying mean scores, not the developed and validated instrument.

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DISCUSSION

Item Response Theory (IRT) of the 3 parameter logistic model (3PL) on the Xcalibre 4.2 software package was employed to obtain the item difficulty, discrimination and guessing parameters (psychometric parameters) of the HEAT. This was done because, according to Fan as cited in Awopeju and Afolabi (2016), the 3 parameter logistic model uses item difficulty, item discrimination and the extent which students can guess the correct answer, as parameters. This contrasts with the Classical Test Theory which measures only item difficulty and discrimination parameters.

Forty-five (45) items out of the 50 items in the Heat Energy Achievement Test were calibrated for item difficulty, discrimination and guessing parameters. Appendix B6 shows the item parameters for all calibrated items. Five items (3, 26, 32, 49 and 50) were unable to be calibrated by the Xcalibre 4.2 software. This was because those items had no variance. In spite of those five items adjudged as having no variance, they were still used for the main study. This is because Sidhu (2007) attributed the state of no variance in the five test items to the fact that all the candidates were of nearly the same ability in each of the items. For instance, 77.42 % of the candidates exhibited low ability in item 3, 72.58% and 87.10% of the candidates exhibited high ability in items 32 and 50.

For item difficulty "B", Guiyer and Thompson (2014) opined that a value below -1.0 indicates very easy item, an item with difficulty index between 1.0-2.99 indicates moderately difficult item and an item with value between 3.0 and above indicates very difficult item. From the analysis, only two items (31 and 42) were easy items, 35 items were moderately difficult, while 8 items were very difficult. The eight items that were adjudged very difficult were revisited and included in the instrument for use in the main study. The items were included in the instrument because Boopathiraj and Chellamani (2013) opined that very difficult items should be reviewed for possible confusing language or the contents need re-instruction.

In reviewing the items that were adjudged very difficult in the test instrument, the following observations were taken care of: Although the option lettered E in item 1 is not the correct option during pilot study, it was a true statement which might have confused the candidates. For the main study, that option was changed to read "The specific latent heat of fusion is released in changing from boiling water to steam". The unit of measurement of specific latent heat of fusion of ice in the options in item 2 was changed from $kJKg^{-1}$ to JKg^{-1} since students could have worked the problem and obtained their solution in JKg^{-1} and might have been confused in changing the answer to $kJKg^{-1}$. The options hydrometer and hygrometer in item 4 sound almost the same and so most candidates wrongly chose hydrometer as their answer to that item. Therefore, that option was changed to 'ammeter' for the main study. In item 5, option C was similar to option D and so option C was changed to read "Mass of vapour". In item 8, options C and E might have gotten the candidates confused as to which was the correct option since both had statements on temperature of ice block. For the main study, option C was changed to read "The ice block does not absorb heat from the atmosphere". Options A and B in item 21 were similar and might have been the source of confusion to the candidates. So, option B was changed to read "3:2". Item 34 was very difficult possibly because the quantity sought after was not clearly stated. Candidates might have been left to wonder as to whether they were required to compute specific latent heat of fusion or vaporization. For the main study, the instruction read as follows: Calculate the specific latent heat of vaporization of the liquid.

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In terms of item discrimination "a", items of low discrimination are those with values less than 0.5. However, all the 45 items calibrated discriminated well among tested candidates since all the values were greater than 0.5. Guiyer and Thompson were of the view that values of "a" that are less than 0.5 can be considered low and those greater than 0.5 and above can be considered okay and better since the purpose of the test is to differentiate between examinees of low and high abilities.

For guessing parameter "C", two items (4 and 5) were prone to guessing, since the values were above the acceptable range of 0.2 for items with 5 options (obtained by dividing 1 by 5). That is, for a five-option item a candidate will have 0.2 chance of obtaining the correct answer. Guiyer and Thompson pointed out that any item with guessing value above 0.25 indicates that the item was prone to guessing. This implies that one incorrect option for that item was easily ignored by all candidates and candidates were guessing among the remaining four options. All the other 43 items out of the 45 items calibrated were not prone to guessing. Two items out of the 8 items that were calibrated as very difficult were prone to guessing; therefore, those items were revisited before the main study was conducted.

CONCLUSION

The study provides evidence for the development and validation of a heat energy achievement test, an instrument which, hopefully, will help Physics teachers to be able to develop and validate test instruments before administering to their students. Research students may also benefit from the findings of this study.

RECOMMENDATIONS

Based on the findings of the study, the researcher recommends that:

1. Ministries of Education, in conjunction with secondary schools, use HEAT as a test instrument for students offering Physics.
2. Postgraduate students of Physics Education and related courses should adopt or adapt HEAT, instead of developing, when carrying out researches involving heat energy measurements.

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APPENDIX 1

HEAT ENERGY ACHIEVEMENT TEST

Section A: Biodata

Instructions: There are fifty (50) questions provided. Answer all questions. Each question is followed by five options lettered A-E. Carefully find out the correct option to each question and circle it. Do not circle more than one option for each question. If you change your mind about an answer, just neatly erase it and circle the one you think is appropriate. Answer all questions.

Time Allowed: $1\frac{1}{4}$ hours

Example: Which of the following is the SI unit of specific latent heat of fusion?

A. M
B. J
C. ms^{-2}
D. Jkg^{-1}
E. $Jkg^{-1}K^{-1}$

1. One of the following best explains why a person suffers a more severe burn when his skin is exposed to steam.
   A. Steam is at a higher temperature than boiling water.
   B. Steam possesses greater heat energy per unit mass than boiling water.
   C. Steam spreads more easily over a wider area of the skin than boiling water.
   D. Steam penetrates more deeply into the skin than boiling water.
   E. The specific latent heat of fusion is released in changing from boiling water to steam.
2. 0.5kg of water at 10^0C is completely converted to ice at 0^0C by extracting 188000J of heat from it. If the specific heat capacity of water is 4200 $Jkg^{-10}C^{-1}$, calculate the specific latent heat of fusion of ice.
   A. $9.0 \times 10^3 J\ kg^{-1}$
   B. $84.0 \times 10^3 J\ kg^{-1}$
   C. $168.0 \times 10^3 J\ kg^{-1}$
   D. $334.0 \times 10^3 J\ kg^{-1}$
   E. $336.0 \times 10^3 J\ kg^{-1}$
3. Which of the following best explains why a scald from steam does more harm than one from boiling water?
   A. Latent heat is found in boiling water.
   B. Specific latent heat of steam is greater than that of boiling water.
   C. Specific heat capacity of steam is less than that of boiling water.
   D. Latent heat is found in steam.
   E. None of the above.
4. Which of the following instruments may be used to measure relative humidity?
   A. Ammeter
   B. Barometer
   C. Manometer
   D. Hypsometer
   E. Hygrometer
5. Which of the following will affect the saturation vapour pressure of a liquid?
   A. Temperature of the liquid
   B. Humidity of air

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C. Mass of vapour
D. Volume of the liquid
E. Mass of the liquid

6. All of the following statements are correct except
A. Evaporation takes place only at the surface of a liquid.
B. Boiling takes place throughout the volume of a liquid.
C. Evaporation takes place at all temperatures.
D. Boiling takes place at a particular temperature for a liquid at a given external pressure.
E. The boiling point of a liquid is not affected by impurities.

7. Calculate the heat energy required to vaporize 50g of water initially at 80^0C if the specific heat capacity of water is 4.2 $Jg^{-1}k^{-1}$ (Specific latent heat of vaporization of water is 2260Jg^{-1})
A. 533,000 J
B. 230,000 J
C. 117,200 J
D. 113,000 J
E. 4,200 J

8. A block of ice at its melting point is left on a table in the atmosphere and it is observed to melt gradually. Which of the following statements is true about the melting process?
A. The reaction force of the table on the ice breaks the ice into water molecules.
B. Heat extracted from the ice block makes the ice block cold.
C. The ice block does not absorb heat from the atmosphere.
D. The atmosphere absorbs heat from the ice block and its temperature falls.
E. The ice block absorbs heat from the atmosphere and its temperature remains constant as it melts.

9. The absolute zero temperature is defined as the temperature at which
A. thermal motion ceases.
B. the temperature of a gas is 273^0C
C. ice melts.
D. the volume of a real gas is maximum.
E. the pressure of a real gas is maximum

10. Two solids P and Q of equal mass are heated to the same temperature and dropped simultaneously into two identical containers X and Y containing equal volumes of water at room temperature. The temperature of X will rise higher than that of Y only if the
A. volume of P is greater than that of Q.
B. specific heat capacity of P is higher than that of Q.
C. density of P is greater than that of Q.
D. density of P is lower than that of Q.
E. specific heat capacity of P is lower than that of Q.

11. How much heat is given out when a piece of iron of mass 50g and specific heat capacity 460 $Jkg^{-1}k^{-1}$ cools from 85^0C to 25^0C?
A. 1.38 x 10^6J
B. 2.53 x 10^4J
C. 7.66 x10^3J
D. 1.38 x 10^3J
E. 1.27 x 10^3J

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12. All of the following are suitable methods for reducing loss of heat from a piece of hot iron except
    A. Wrapping it in cotton wool.
    B. Painting it black.
    C. Placing it in vacuum.
    D. Placing it on rubber supports.
    E. Keeping it in a closed wooden box
13. The boiling point of a liquid depends on the following except the
    A. nature of the liquid
    B. external pressure
    C. volume of the liquid
    D. impurities present in the liquid
    E. degree of its molecular cohesive force.
14. A steam trap is a component of the apparatus used in determining the specific latent heat of vaporization of steam. Explain the effect of the steam trap in the steady state.
    A. The steam trap stores the steam for future use.
    B. The steam trap prevents the steam from escaping.
    C. The steam trap ensures that only dry steam gets into the colorimeter.
    D. The steam trap allows condensed steam to go into the colorimeter.
    E. The steam trap determines the quantity of steam used.
15. A tap supplies water at 26^0C while another supplies water at 82^0C. Calculate the ratio of mass of hot water to that of cold water required, if a man wishes to bathe with water at 40^0C.
    A. 1:3
    B. 3:1
    C. 3:7
    D. 7:3
    E. 15:8
16. One of the following best describes why melting ice cools an orange drink far better than the same mass of ice-cold water.
    A. Melting ice is at lower temperature than ice-cold water.
    B. Water has a higher specific heat than ice.
    C. Ice floats and cools the air above the drink.
    D. Ice absorbs latent heat during melting.
    E. Ice makes better thermal contact than water.
17. In a pressure cooker, water is boiled under
    A. Reduced pressure
    B. increased pressure
    C. increased heat
    D. reduced heat
    E. normal heat
18. A metal of mass 1.5kg was heated from 27^0C to 47^0C in 4 minutes by a boiling ring of 75W rating. Calculate the specific heat capacity of the metal (Neglect heat losses to the surrounding).
    A. 2.5×10^3 J kg^{-1} $^0C^{-1}$
    B. 6.0×10^2 J kg^{-1} $^0C^{-1}$
    C. 2.5×10^2J kg^{-1} $^0C^{-1}$
    D. 1.4×10^2 J kg^{-1} $^0C^{-1}$

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E. 1.0 x 10 J kg^{-1} $^0C^{-1}$

19. When two objects P and Q are supplied with the same quantity of heat, the temperature change in P is observed to be twice that in Q. If the masses of P and Q are the same, calculate the ratio of the specific heat capacities of P to Q.
A. 1:1
B. 1:3
C. 1:4
D. 1:2
E. 4:1

20. Calculate the heat required to convert 20g of ice at 0^0C to water at 16^0C, if the specific latent heat of fusion of ice is 3.36 $Jg^{-1}$and the specific heat capacity of water is 4.2 $Jg^{-1}K^{-1}$.
A. 1.34 x 10^3J
B. 5.38x 10^3J
C. 6.70x 10^3J
D. 7.06x 10^3J
E. 1.41 x 10^3J

21. A tap supplies water at 30^0C while another supplies water at 86^0C. If a man wishes to bathe with water at 44^0C, calculate the ratio of the mass of hot water to that of cold water required.
A. 1:3
B. 3:2
C. 3:7
D. 7:3
E. 15:8

22. 500g of water is heated so that its temperature rises from 30^0C to 72^0C in 7 minutes. Calculate the heat supplied per minute (Specific heat capacity of water = 4200 $Jkg^{-1}K^{-1}$).
A. 9000 J
B. 12600 J
C. 21000 J
D. 25200 J
E. 88200 J

23.

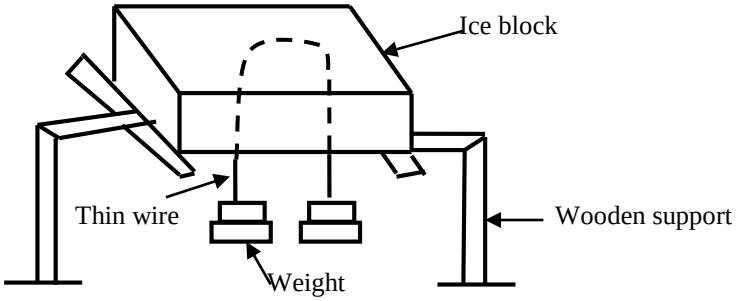

Fig. 1

Fig. 1 shows a block of ice resting on two wooden supports. A thin wire with heavy weights is hung over the block of ice. After sometime the following happens except
A. The wire cuts right through the ice block.

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B. The ice block does not break, even though the wire cuts through the block and falls to the ground.
C. The ice block remains on the support.
D. The wire cuts the ice block into two.
E. The ice block appears as if the wire did not pass through it.

24. An electric kettle rated at 1500W boils away 0.3kg of a liquid at its boiling point in 300s. Calculate the specific latent heat of vaporization of the liquid.
A. $1.50 \times 10^{6} Jkg^{-1}$
B. $1.35 \times 10^{5} Jkg^{-1}$
C. $1.50 \times 10^{5} Jkg^{-1}$
D. $4.50 \times 10^{2} Jkg^{-1}$
E. $3.00 \times 10^{2} Jkg^{-1}$

25. 80% of the heat supplied to a 30g block of ice at $0^{0}C$ completely melts it to water at $0^{0}C$. Calculate the total heat energy supplied (Specific latent heat of ice=$336 Jg^{-1}$).
A. 26800 J
B. 12600 J
C. 10080 J
D. 8064 J
E. 4200 J

26. A body of specific heat capacity $450 Jkg^{-1}K^{-1}$falls to the ground from rest through a vertical height of 20m. Assuming conservation of energy, calculate the change in temperature of the body on striking the ground level (g =$10 ms^{-2}$)
A. $0\ ^{0}C$
B. $2/9\ ^{0}C$
C. $4/9\ ^{0}C$
D. $9/4\ ^{0}C$
E. $9/2\ ^{0}C$

27. Hot water at a temperature of t is added to twice that amount of water at a temperature of $30^{0}C$. If the resulting temperature of the mixture is $50^{0}C$, calculate t.
A. $90\ ^{0}C$
B. $80\ ^{0}C$
C. $50\ ^{0}C$
D. $40\ ^{0}C$
E. $30\ ^{0}C$

28. An iron rod of mass 2kg and at a temperature of $280^{0}C$ is dropped into some quantity of water initially at a temperature of $30^{0}C$. If the temperature of the mixture is $70^{0}C$, calculate the mass of the water. Neglect heat losses to the surroundings. (specific heat capacity of iron = $460 Jkg^{-1}K^{-1}$; specific heat capacity of water = $4200 Jkg^{-1}K^{-1}$)
A. 0.58kg.
B. 0.77kg
C. 1.15kg
D. 1.50kg
E. 2.04kg

29. How much heat is required to convert 20g of ice at $0^{0}C$ to water at the same temperature? (Specific latent heat of ice = $336\ Jg^{-1}$).
A. $1.35 \times 10^{3} J$
B. $5.38 \times 10^{3} J$
C. $6.72 \times 10^{3} J$

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D. 7.06x 10^3J
E. 8.06x 10^3J

30. All of the following statements are correct except
A. Heat energy can be transformed into mechanical energy.
B. The total heat content of a body is the sum of the kinetic energies of its molecules.
C. If a body is heated, its molecules move faster.
D. If a body is cooled, molecular movement remains constant.
E. The energy of a body is measured in joules.

31. Calculate the difference in the amount of heat given out by 4kg of steam and 4kg of water when both are cooled from 100^0C to 80^0C? (Specific latent heat of steam = 2, 260,000 J kg^{-1}; specific heat capacity of water = 4, 200 $Jkg^{-1}K^{-1}$)
A. 336,000 J
B. 672,000 J
C. 8,704,000 J
D. 9,040,000 J
E. 9,376,000 J

32. The phenomenon that occurs in Fig. 1 is known as
A. freezing
B. boiling
C. regelation
D. vaporization
E. fusion

33. Cloud formation is the direct result of
A. precipitation
B. vaporization
C. fusion
D. sublimation
E. condensation

34. All the heat generated in a 5Ω resistor by 2A current flowing for 30s is used to evaporate 5g of liquid at its boiling point. Calculate the specific latent heat of vaporization of the liquid.
A. 100 Jg^{-1}
B. 130 Jg^{-1}
C. 125 Jg^{-1}
D. 140 Jg^{-1}
E. 120 Jg^{-1}

35. Humidity is used to describe the amount of
A. air in water vapour
B. cloud available in the atmosphere
C. air in equal volumes of cloud
D. water vapour in the atmosphere
E. gas in a volume of water

36. Which of the following statement(s) is/are correct?
I. Increased pressure lowers the melting point of ice.
II. Decreased pressure lowers the melting point of ice.
III. The quantity of heat required to melt a given mass of substance is constant.
IV. The temperature at which melting starts is not affected by the pressure applied to a solid.

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A. All statements are correct
B. I, II and III only
C. II and IV only
D. I, III and IV only
E. I and III only

37. Which of the following defines sublimation?
A. A process whereby a substance changes from liquid to vapour without going through the solid state.
B. A process whereby a substance changes from solid to vapour without going through the liquid state.
C. A process whereby a substance changes from liquid to solid without going through the vapour state.
D. A process whereby a substance changes from solid to vapour, by going through the liquid state.
E. A process whereby a substance changes from liquid to solid, by going through the vapour state.

38. The pressure cooker is most useful in areas where
A. Atmospheric pressure is high
B. water pressure is low
C. water pressure is high
D. water pressure is zero
E. Atmospheric pressure is low

39. Figure 2 shows the cooling curve of naphthalene.

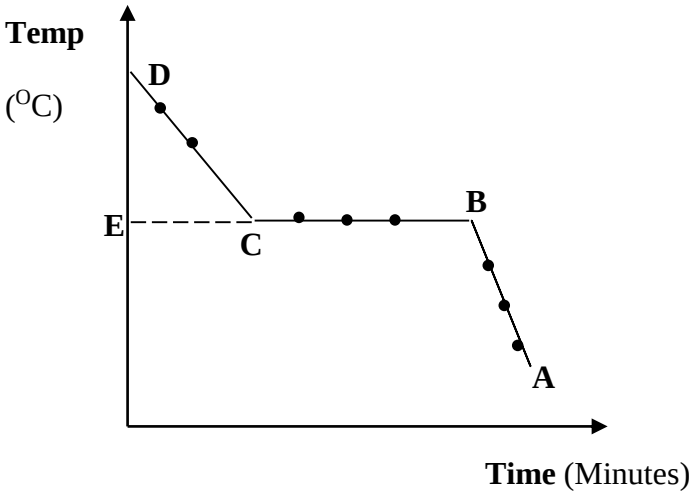

Fig. 2

Which of the following concepts can be determined from the figure?
A. Melting point
B. Boiling point
C. Dew point
D. Sublimation
E. Freezing point

40. What happens between the points D and C in Fig. 2? The temperature
A. rises with time.

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B. falls with time
C. becomes constant
D. remains unchanged
E. is equal to the boiling point of naphthalene

41. In Fig. 2 the flat portion (CB) indicates that
A. heat energy lost to the surroundings is balanced by the heat given out as naphthalene changes from liquid to solid.
B. heat energy lost to the surroundings is less than the heat given out as naphthalene changes from liquid to solid.
C. heat energy lost to the surroundings is greater than the heat given out as naphthalene changes form liquid to solid
D. the heat energy lost to the surroundings.
E. the heat energy given out as naphthalene changes from liquid to solid.

42. Which of the following best defines a volatile liquid?
A. A liquid that has a low boiling-point and changes from liquid to vapour at very high temperatures.
B. A liquid that has high boiling-point and changes from liquid to vapour at ordinary temperatures.
C. A liquid that has a low boiling-point and changes from liquid to vapour quite easily at ordinary temperatures.
D. A liquid that has high-boiling point and changes from vapour to liquid quiet easily at ordinary temperature.
E. A liquid that has a low melting point and changes from liquid to vapour quiet easily at ordinary temperatures.

43. In which of the following household appliances is the application of latent heat found?
A. Television set
B. Radio set
C. Electric cooker
D. Refrigerator
E. Domestic hot water supply

44. Consider fig 3 on changing 4g of ice at 0^0C to water at 10^0C

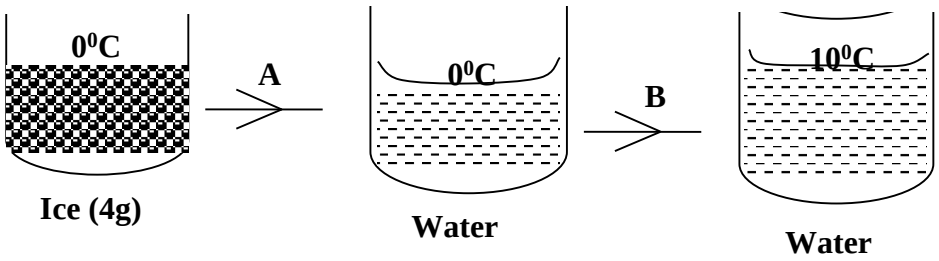

Fig. 3

Select the correct statement(s) from the following:
I. Change of state occurs in stages A and B.
II. Latent heat occurs in stage A only
III. Temperature remains constant in stage A
IV. Mass of iceis less than the mass of water

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A. I only
B. All statements are correct
C. II and III only
D. IV only
E. III and IV only

45. Calculate the heat energy required to change the ice to water at 0^0C in fig. 3. (Specific latent heat of ice = $320Jg^{-1}$).
A. 1.28×10^4J
B. 2.50×10^3 J
C. 3.15×10^3 J
D. 1.28×10^3 J
E. 2.50×10^4J

46. One of the following best defines relative humidity.
A. The ratio of the mass of water vapour present in a certain volume of air to the mass of water vapour required to saturate the same volume of air at the same temperature.
B. The values used by weather casters for making weather casts.
C. The mass of water vapour present in a certain volume of air to the mass of water vapour required to saturate the same volume of air at the same temperature.
D. The humidity of the water vapour present in the air.
E. The temperature of water vapour present in the air.

47. Which of the following statement best describes boiling?
A. Boiling is the temperature at which the air present in the water is just sufficient to saturate the water.
B. Boiling is the process whereby bubbles of vapour which appear in a liquid rise to the liquid surface as the temperature of the liquid steadily increases.
C. Boiling is a vapour that is in contact with its own liquid within a confined space.
D. Boiling is the temperature of boiling water.
E. Boiling is the process of changing solid to liquid.

48. The rate of cooling of a liquid depends on which of the following?
I. Its temperature
II. The temperature of the enclosure
III. The area of the exposed surface
IV. The nature and extent of the surface of the containing vessel
A. All statements are correct
B. I, II and III only
C. IV only
D. II and III only
E. I only

49. A body of mass m has a specific heat capacity s and a heat capacity c. If the temperature of the body changes by θ ^{0}C, select the correct equations from the following:
A. $ms\theta = mc^{-1}$
B. $ms = c$
C. $ms = s\theta$
D. $ms = c\theta$
E. $m\theta = sc$

50. Which of the following best defines specific heat capacity of a substance?
A. The quantity of heat energy needed to raise the temperature of the entire substance through one degree rise in temperature.

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B. The quantity of heat energy needed to change the substance from its solid to liquid state without change in temperature.
C. The quantity of heat energy needed to change the substance from its liquid to vapour state without change in temperature.
D. The quantity of heat energy needed to change the substance to ice without change in temperature.
E. The quantity of heat energy needed to raise the temperature of unit mass of the substance through one degree rise in temperature.

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