T325 – BLOCK 1

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T325 Summary

Session 1

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T325

Introduction to hardware, Software and data

Q1: **Power consumption** is one of the main constraints on the design of electronic goods, and is a major consideration for mobile devices and even for mains-power equipment

Answer: True

Q2: Most of the power consumed ends up as heat.

Answer: True

Q3: The lithium ion battery first commercialized by Sony in 1991, it stores energy a factor of 5 higher than that stored by the much older lead-acid batteries.

Answer: True

Q4: Receivers for digital audio broadcasting (DAB) available at the moment typically consume a lot more power than receivers for analogue radio broadcasts.

Answer: True

Q5:**Batteries produce electricity** from a **chemical reaction**, called an **electrochemical reaction**.

Answer: True

Q6:**Batteries produce electricity** from a___________________, called an **electrochemical reaction**.

A) chemical reaction
B) power reaction
C) Natural reaction
D) No one

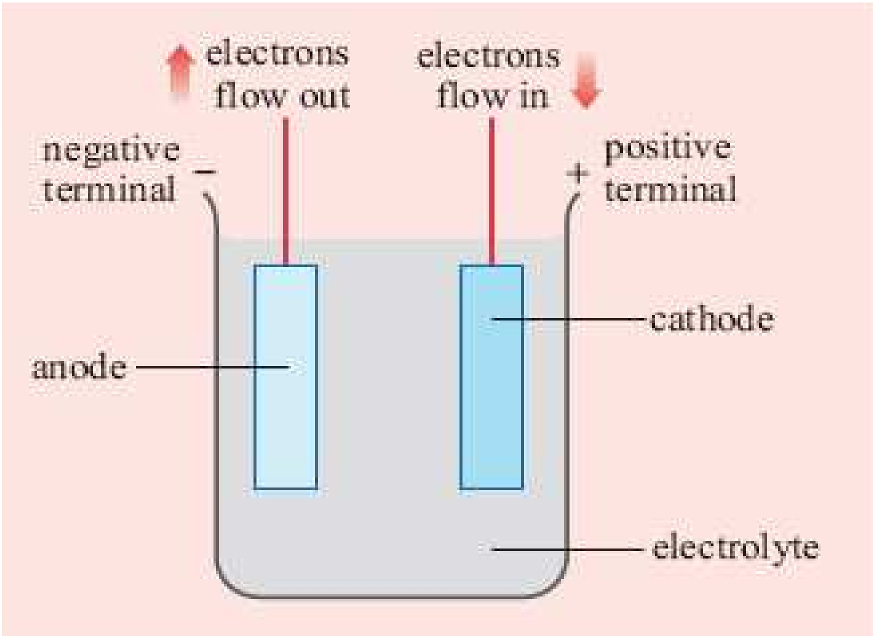
Answer: A) checmical reaction

Q7:**Batteries produce electricity** from a checmical reaction, called an__________________________.

A) chemical reaction
B) electrochemical reaction
C) Natural reaction
D) No one

Answer: B) electrochemical reaction

Q8:List the main component elements of any batteries.



Answer:

- **Electrodes**
    - **Anode**
    - **Cathode**
- **Electrolyte**
- **The chemical reaction depends upon the material used to make the anode, the material used to make the cathode and the material used for the electrolyte.**

Q9:List some types of batteries.
Answer:

- **Lead-acid batteries**
- **Alkaline batteries**
- **Nickel--cadmium (NiCd)**
- **Nickel-metal hydride (NiMH)**
- **Lithium**
- **Lithium-ion (Li-ion) batteries.**

Q10: The chemistry, as well as the details of the physical construction, determines whether the batteries can be **recharged** or **not**.
Answer: True

Q11: List two categories of batteries.
Answer:
- **Primary batteries**
    - **Manufactured to be used once**
    - **Examples: alkaline and lithium batteries**
- **Secondary batteries**
    - **Rechargeable**

Q12: What doem it mean by term "**Elements**"?
Answer:
Elements: The purest substances of the physical world are the elements (nickel, cadmium, zinc, potassium,).

Q13: What doem it mean by term "**Compounds**"?
Answer:
Compounds: Most elements can join to other elements to form compounds. (hydrogen joined (in an appropriate way) to oxygen forms water.)

Q14: What doem it mean by term "**Checmical reaction**"?
Answer:
Chemical reaction: When elements combine to form a compound the process is called a chemical reaction. Chemical reactions can also take place between two or more compounds or between elements and compounds.

Q15: What doem it mean by term "**Atoms**, **molecules** and **ions**"?
Answer:
Atoms, molecules and ions: The basic building block of an element is an atom. An atom consists of a nucleus, which has a positive electrical charge, and electrons, which have a negative electrical charge

Q16: The voltage of a battery cell is determined primarily by the materials used for the electrodes and the electrolyte.
Answer: True

Q17: To get higher voltages, cells are connected in series, with the result that the voltages add.
Answer: True

Q18: The voltage determined by the chemistry will only be found at its **maximum** when no current is being drawn from the battery.
Answer: True

Q19: The current drawn from the battery in any application is determined by the load and by the battery voltage.
Answer: True

Q20: A battery that can deliver high currents will have a low internal resistance.
Answer: True

Q21: One that cannot deliver high currents will have a high internal resistance.
Answer: True

Q22: A battery that can deliver high currents will have a____________________.
A) low internal resistance
B) high interal resistance
C) equal interal resistance
D) No one

Answer: A) low interal resistance

Q22: A battery that can not deliver high currents will have a____________________.
A) low internal resistance
B) high interal resistance
C) equal interal resistance
D) No one

Answer: B) high interal resistance

Q24: In the International System of Units (SI) units, Energy is measured in joules (J) and power in watts (W).
Answer: True

Q25: In the International System of Units (SI) units, Energy is measured in _______________and power in ______________.
A) joules (J), watts (W)
B) watts (W), joules (J)
C) ohms, watts (W)
D) ohms, joules (J)

Answer: A) joules (J), watts (W)

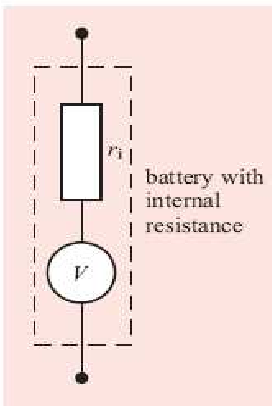
Q26: 1W corresponding to energy being transferred at a rate of one joule per second (1 J/s).
Answer: True

Q27:

a) If the battery voltage is V volts and the load has a resistance of R ohms, what current flows from the battery?
b) On a single graph, plot the current against resistance for a 1.5V battery and a 3.6V battery, for a resistance range of 10 to 200 ohms.

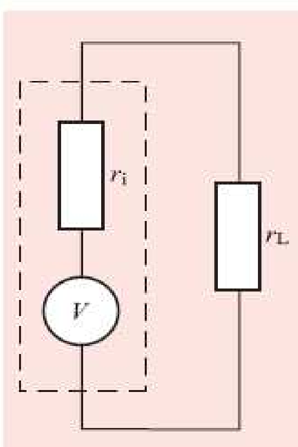
a) **Answer: From Ohm's law, the current is given by the voltage divided by the resistance, V/R.**

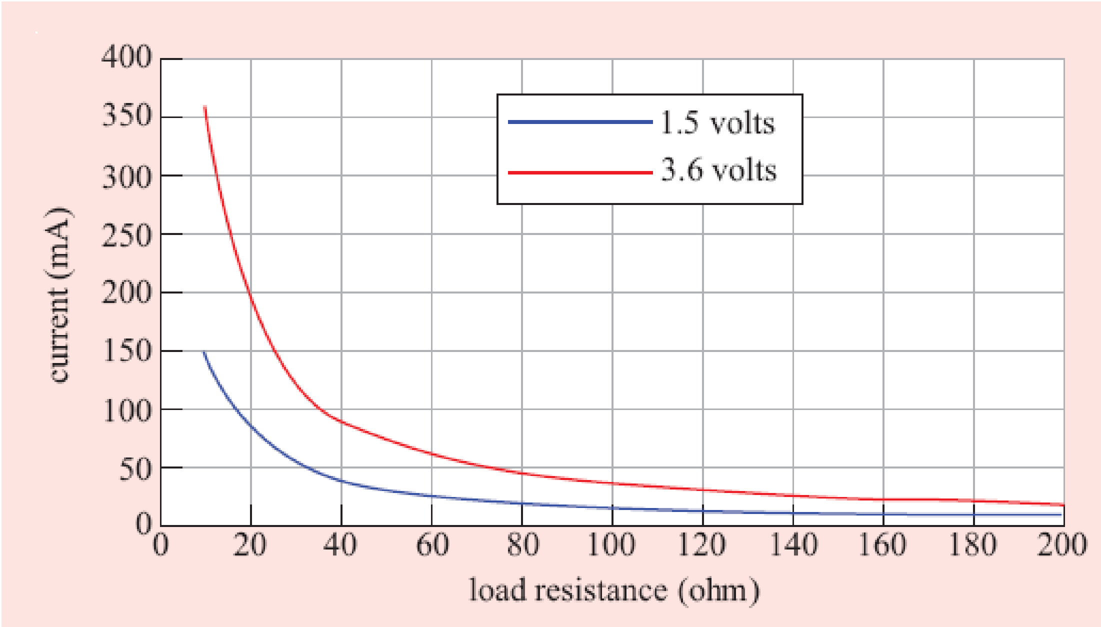
i= V / ri



A) **i= V / ri + rL**

$$i = \frac{v}{r_i + r_L}$$





Q28: What does it mean by term "Capacity"?

Answer: The length of time a battery can supply a given power is determined by the amount of energy stored in the battery.

Q29: A battery storing 10 kJ (10000 J) could ideally run for 10000 s delivering 1W.

Answer: True

Because => K = 1000, so 10 X 1000 J = 10000 J

Q30: Express the battery capacity in terms of **amp-hours (Ah)**, amps multiplied by hours.

Answer:

For example, a battery with a capacity of 1 Ah could supply 1 A for 1 h, or else it could supply 2 A for 0.5 h or 0.5A for 2 h. More generally, if a battery can run at a current *i* for *t* hours, then its capacity is capacity = $i \times t$.

Q31: A 1.2V battery has a capacity of 800 mAh. How long could it run if the load uses 50 mA?

Answer:

Capacity = i x t

Capacity = 800 mAh

Load i = 50 mA

So, 800 mAh = 50 mA x t

- **t = capacity / t**
- **t = 800 mAh / 50 mA**
- **t= 16 h**

Q32: A 1.2V battery has a capacity of 800 mAh. How long could it run if the load has a resistance of 30 ohm?

Answer:

First step we have to find the current drawn from the battery, which

- ⇨ **The current drawn from the battery is 1.2/30 = 0.04 A,**

Second step we have to convert measure of the 0.04 A to mA, which

- ⇨ **0.04 x 1000 = 40 mA**

Third step we have to find the h, by using (capacity=ixt), which

Capacity = i x t

Capacity = 800 mAh

Load i = 40 mA

So, 800 mAh = 40 mA x t

- ⇨ **t = capacity / t**
- ⇨ **t = 800 mAh / 40 mA**
- ⇨ **t= 20 h**

so, it could run 20 h

Q33: The time *t* the battery can be used is given by *t*= capacity / *i*.

Answer: True

Q34: Small digital devices, such as mobile phones, typically draw rather less than 1A, so it is more convenient to work in terms of milliamps (mA) rather than amps,

Answer: True

Q35: A 1.2V battery is specified to have a capacity of 800 mAh. What energy does the battery store? Give your answer in both watt-hours and joules.

Answer:

First step: try to convert the measure of capacity 800 mAh to Ah, which,

- ⇨ **800/1000 = 0.08 Ah**

Second step: try to find the battery stores in Wh, which,

- ⇨ **1.2 x 0.8 = 0.96 Wh**

Thrid step: try to find the battery stores in Jouels (J), which,

- ⇨ **0.96 x h**
- ⇨ **h= seconds x minutes**
- ⇨ **h= 60x60**
- ⇨ **h=3600 (1h)**
- ⇨ **so, 0.96 x 3600**
- ⇨ **battery stores in jouels = 3456 J**
- ⇨ **we can round the j to 3460 j or 3500 j**

Since the 800 mAh specification for the battery capacity can only be approximate, and the usable energy is anyway dependent upon factors such as temperature and the current being drawn from the battery, it would not be meaningful to express the energy stored in the battery to four significant figures. Without knowing any further details of variation that could be expected from the capacity, I would round the answer here to two significant figures, giving it as 3500 J

Q36: What is 1kWh expressed in joules?

Answer:

- ⇨ **1k = 1000**
- ⇨ **h=seconds x miniutes**
- ⇨ **h=60x60**
- ⇨ **h=3600**
- ⇨ **so, 1kwh = 1000 x 3600 = 3 600 000 j, which is 3.6 Mj**

Q37: we can compare batteries in (**weight**, **size** and **capacity**).

Answer: True

Q38: What does it meany by term “Volumetric energy density”?

Answer: *the amount of energy stored per unit volume*. In SI units, It can be expressed in units of joules per metre cubed (J/m^3).

Q39: What does it meany by term “Gravimetric energy density”?

Answer: *is the amount of energy stored per unit mass*.

Note: Gravimetric energy density SI unit is joules per kilogram (J/kg), Other units can be used such as watt-hours per gram (Wh/g) and kilowatt-hours per kilogram (kWh/kg).

Q40: What does it meany by term “Volumetric power density”?

Answer: *the power that can be delivered, per unit volume*.

Note: The volumetric power density SI unit is W/m^3
There are various units that could be used, such as watts per centimetre cubed (W/cm3) or watts per litre (W/L).

Q41: What does it meany by term “Gravimetric power density”?

Answer: *the amount of power that can be delivered per unit mass*.

Note: The gravimetric power density SI unit is W/Kg

Other units might be used, such Watt per gram (W/g), Kilo-Watt per Kg (KW/Kg), etc.

Q42: Suppose a battery has the following parameters:

- ⇨ voltage, 1.2V
- ⇨ capacity, 800mAh
- ⇨ weight, 24 g
- ⇨ volume, 8.4cm3

Calculate the volumetric energy density and the gravimetric energy density of this battery.

For the volumetric energy density, give your answer in both J/cm3 and Wh/L, and for the gravimetric energy density give your answer in both J/kg and Wh/kg. Give all your answers to two significant figures.

Answer:

First Step: try to change the measures according to output

- ⇨ voltage, 1.2V
- ⇨ capacity, 800mAh (800/1000=0.8 Ah)
- ⇨ weight, 24 g (24/1000=0.024 kg)
- ⇨ volume, 8.4cm3 (8.4/1000=0.0084 L)

Second step: try to find:

- ***Battery capacity in watts hour = 1.2 x 0.8 = 0.96 Wh.***
- ***Battery capacity in joules, this is 0.96 x 3600 = 3456 J.***

Note: To three significant figures, 3460 J (use three significant figures for intermediate results).

Third step: try to find the volumetric energy density, which,

Volumetric energy density for jouels, (J/cm^3)

- ***Volumetric energy density = 3460/8.4 = 410 J/cm^3.***

Volumetric energy density for watts hour/L, (Wh/L)

- ***Volumetric energy density = 0.96/0.0084 = 110 Wh/L.***

Fourth step: try to find the gravimetric energy density, which,

Gravimetric energy density for jouels, (J/kg)

- ***Gravimetric energy desntiy = 3460/0.024 = 140 000 J/kg.***

Gravimetric energy density for watts hour /Kilo grames, (wh/kg)

- ***Gravimetric energy desnity = 0.96/0.024 = 40 Wh/kg.***

Q43:

- ⇨ Suppose the battery of Activity 1.13 can deliver a current of 1A. Calculate its volumetric power density in W/L and its gravimetric power density in W/kg, assuming the battery voltage is 1.2V.
- ⇨ weight, 24 g
- ⇨ volume, 8.4cm3

a) Drawing such a high current, the battery voltage will fall quite quickly. Calculate the same figures as in part (a) for when the battery voltage has dropped to 0.8V.

Answer:

- ⇨ weight, 24 g (24/1000=0.024 kg)
- ⇨ volume, 8.4cm3 (8.4/1000=0.0084 L)

First Step: try to find the current power in watts, which,

a) 1 A at 1.2V is a power of 1.2W.

Second step: try to find the volumetric power desnsity in watts per Litter,(w/l)

- ***Volume (from previous activity) is 0.0084 L. So the volumetric power density is 1.2/0.0084 = 140 W/L.***

Third step: try to find the gravimetic power desnity in W/kg, which,

- ***The mass (from the previous activity) is 0.024 kg, so the gravimetric power density is 1.2/0.024 = 50 W/kg.***

Fourth step: try to find the volumetric power density, when the voltage dropped to 0.8V.

b) 1 A at 0.8V is a power of 0.8W. So the volumetric power density is 0.8/0.0084 = 95 W/L.

- ***The gravimetric power density is 0.8/0.024 = 33 W/kg.***

Q44:**Some batteries cannot be recharged at all**. These are known as **primary batteries**, contrasted with secondary batteries which can be recharged.

Answer: True

Q45: Even a secondary battery, which can be recharged, will be limited in the number of times it can be recharged before it deteriorates so that it no longer retains charge very effectively.

Answer: True

Q46: A battery is charged by passing an electrical current through it in the opposite direction from the direction that current flows when it is in use.
Answer: True

Q47: Mention some general rules that it is important for battery charging and safy.
Answer:
- **Not to attempt to charge a battery too fast and that the charging should stop once the battery is fully charged.**
- **For example: Li-ion batteries need careful charging, Care also needs to be taken over the discharging of Li-ion batteries.**
- **Discharging a battery too fast, such as if there were to be a wire connecting the anode to the cathode directly (called a 'short circuit'), can result in a battery overheating. and this can result in the battery exploding.**
- **To ensure that none of these damaging or dangerous circumstances occur, Li-ion batteries are supplied packaged with control and protection electronics, which might even include 'intelligence': a microprocessor that controls the battery is referred to as a smart battery.**

Q48: Li-ion batteries need careful charging, Care also needs to be taken over the discharging of Li-ion batteries.
Answer: True

Q49: Discharging a battery too fast, such as if there were to be a wire connecting the anode to the cathode directly (called a '**short circuit**'), can result in a battery overheating. and this can result in the battery exploding.
Answer: True

Q50: What does it mean by term "Shelf life", giving an example?
Answer: The shelf life of a battery is the length of time a battery can be stored, even if it is not being used.

Example: shelf life can be very important in some applications - (example of military applications).

Q51: What does it mean by term "Self Discharge", giving an example?
Answer: When not in use, all batteries gradually lose charge.

Example: Standard NiMH batteries can lose as much as 20--30% of their charge in a month, and Li-ion batteries of the order of 5% per month.

Q52: The Primary batteries are very inefficient in the use of energy.
Answer: True

Q53: The Secondary batteries are generally more efficient in these terms than primary batteries, but it still takes substantially more energy to recharge a battery than you get out of it from the charging.
Answer: True

Q54: What are the environmental issues related to the use of primary and secondary batteries.
Answer:

- ***Primary batteries***
  - *Very inefficient in the use of energy.*
  - *The amount of energy used to manufacture a battery is much greater than the amount of energy that will be usefully delivered to the equipment.*
- ***Secondary batteries***
  - *Generally more efficient in these terms than primary batteries, but it still takes substantially more energy to recharge a battery than you get out of it from the charging.*
  - *Disposing of used batteries can damage the environment.*

Q55: The idea that **fuel cells** might be used to **generate electricity** for **small portable devices** like laptops is a relatively recent development.
Answer: True

Q56: Mention some interest field research in fuel cell batteries.
Answer:

- ***Increasing demand for power by digital devices***
- ***Inability of batteries to keep up***
- ***The attraction of being able to revive a laptop by pouring in a cupful of liquid fuel***
- ***Aims of research in fuel cells batteries***

⇨ ***Producing a small, cheap and safe fuel cell for electronic devices***

Q57: A fuel cell is an electrochemical energy conversion device.
Answer: True

Q58: A fuel cell is produces electricity from various external quantities of fuel (on the **anode side**) and **oxidant** (on the **cathode side**).
Answer: True

Q59: What is the different between fuel cells and batteries.
Answer:

- ***Fuel cells are different from batteries in that they consume reactant, which must be replenished, whereas batteries store electrical energy chemically in a closed system.***

Q60: What does it mean by term "**Energy scavenging or energy harvesting**"
Answer:
Finding ways of picking up power from the environment.

Q61: What is the aim of using "**Energy scavenging or energy harvesting", giving an example.**
Answer:

- ***Reduces the amount of energy being drawn from a battery.***
- ***Examples: solar-powered calculators are in fact harvesting energy from the ambient light and have been around for decades.***
- ***A very important area of application of energy harvesting: providing power for wireless sensor networks.***

Q62: At present, most energy for digital devices, as for all electrically powered equipment, ultimately can be traced back to fossil fuels.
Answer: True

Q63: Explain of using fossile fuels in most energy for digital devices.
Answer:

- ***find alternatives to fossil fuels***
- ***reduce energy consumption (responsibility of the ICT industry)***
- ***European Union established a framework for the setting of eco-design requirements for energy-using products***

Q64: Read the following announcement from Samsung, and use the information in it to answer the following questions.

Korea's Samsung Electronics has developed a docking station equppied with a fuel cell of powering a laptop a month.

Desingned Samsung's Q35 ultraportale laptop, the docking station a 1200 Wh fuel cell, report engadged. The dock is capable of powring a loptop eigth hours a day, five days a week for a month. A miniature version is under development which can power a laptop for more than 15 hours on a coffee cup's worth of fuel.

The dock uses a Direct Methanol Fuel Cell with a maximum output of 20 W. DMFCs are best suited to producing small amount of power over long period at low tempretures, making them well suited to mobile device. Samsung claims the cell's 650 W/L energy density is roughly four times that its competitors.

Samsung plans to launch the dock at the end of 2007.

a) Estimate the assumed running power of the laptop, averaged over a month (assume there are four weeks in a month).
b) How many litres of fuel must there be in the docking station?

Approximately how many litres of fuel does the writer assume are contained in a coffee cup?

Answer:

a) It uses 1200Wh to run for 8 h a day, 5 days a week, for a month (which we take to be 4 weeks). At 5 days per week that is 20 days, and 8 h a day gives 160 h.

⇨ So the power drawn must be 1200/160 = 7.5W.

b) 1200Wh with a volumetric energy density of 650 Wh/L means it must use 1200/650 = 1.85 L.

c) It is supposed to be able to run for 15 h on 'a coffee cup's worth of fuel'. So 15 h would need 15 x 7.5 = 112.5 Wh. This would need 112.5/650 = 0.173 L. (This is about 1/3 of a pint, which is reasonable.)

Q65: The batteries that can be re recharged are called:

a) Primitive batteries
b) Secondary batteries
c) Alkaline batteries
d) Primary batteries
e) Tertiary batteries

Answer: b) Secondary batteries

Q66: The length of time a battery can be stored, even if it is not being used is called:

a) Shelf life
b) Self discharge time
c) Battery lifetime
d) Battery storage period

Answer: a) Shelf life

Q67: Picking up power from the environment is called:

a) Energy saving
b) Energy consumption
c) Power saving
d) Natural energy
e) Energy harvesting

Answer: e) Energy harvesting

Q68: 1.2V battery is specified to have a capacity of 800 mAh stores.

a) 0.96 J
b) 960 Wh
c) 960 J
d) 96 J
e) 3456 J

Answer: e) 3456 J

Because of :

⇨ First step: convert the capacity measure from mAh to Ah, which,
⇨ 800/1000 = 0.08 Ah
⇨ Second step: 1.2 X 0.08 = 0.96 Wh
⇨ Third step: to find the Jouels: 0.96 X 3600 = 3456 J

Q69: Consider the following specifications of a laptop battery

- Battery Type : Li-ion
- Voltage : 11.1V
- Capacity : 6600mAh
- Dimension : 209.40 x 71.80 x 19.80mm
- Net Weight : 578.33 g

a. Calculate the volumetric and gravimetric energy density of this battery in SI units.
b. How much time this battery can deliver a current of 1.5A?
a. What are the gravimetric and volumetric power density (in SI unit) when the battery delivers a current of 1.5 A?

Answer:

Question A: Calculate the volumetric and gravimetric energy density of this battery in SI units.

The first step: to convert all measures:

- Converting the Capacity : 6600mAh to Ah, which,

⇨ 6600 / 1000 = **6.6 Ah**

- Dimension : 209.40 x 71.80 x 19.80mm, which,

- ⇨ Volume = 209.40 x 71.80 x 19.80 = **297691.416 mm^3**
- ⇨ **297691.416 / 1000 = 297.691416 m**
  - Converting Net Weight : 578.33 g to KG, which,
- ⇨ 578.33 / 1000 = **0.57833 Kg**

Second step: try to find:

- ***Battery capacity in watts hour = 11.1 x 6.6 = 73.26Wh.***
- ***Battery capacity in joules, this is 73.26 x 3600 = 263736 J.***

Third step: try to find the volumetric energy density in J/m^3, which,
Volumetric energy density for jouels, (J/m^3)

- ***Volumetric energy density = 263736/297.691416 m= 885.937 J/m^3.***

Fourth step: try to find the gravimetric energy density, which,
Gravimetric energy density for jouels, (J/kg)

- ***Gravimetric energy desntiy = 263736/0.57833 = 456030.294 J/kg.***

Question B: How much time this battery can deliver a current of 1.5A?

- ⇨ **Capacity = ixt**
- ⇨ **Capacity = 6.6 Ah**
- ⇨ **Current (i) = 1.5 A**
- ⇨ ***6.6 Ah = 1.5 A x t***
- ⇨ ***t= 6.6 Ah / 1.5 A = 4.4 h***

Question C: What are the gravimetric and volumetric power density (in SI unit) when the battery delivers a current of 1.5 A?

The first step: to find the power in Watts:

- ⇨ Power = Voltage x Current
- ⇨ Voltage = 11.1 v
- ⇨ Current = 1.5 A
- ⇨ 11.1 x 1.5 = 16.65 W

The Second step: to find Volumetric Power Density:

- ⇨ Volumetric Power Density = Power / Volume
- ⇨ Power = 16.65 W
- ⇨ Volume = 297.691416 m
- ⇨ 16.65 / 297.691416 = 0.055930 W/m^3

The Third step: to find Gravimetric Power Density:

- ⇨ Gravimetric Power Density = Power / Mass
- ⇨ Power = 16.65 W
- ⇨ Mass = 0.57833 Kg
- ⇨ 16.65 / 0.57833 = 28.78 W/Kg

Q70: Define the two following terms: Self-discharge and Shelf life.

Answer:

- **Self-Discharge: A process when not in use, all batteries gradually lose charge.**
- **Shelf life: the shelf life of a battery is the length of time a battery can be stored even if it is not being used.**

Q71: Assuming that a battery has the following parameters:

- Voltage, 1.6V
- Capacity, 550 mAh
- Weight, 20 g
- Volume, 6.4cm3

a. You are asked to calculate the volumetric energy density and the gravimetric energy density of this battery. For the volumetric energy density, give your answer in J/cm3, and for the gravimetric energy density give your answer in both Wh/kg. Give all your answers to two significant figures.

Answer:

The first step: is converting the measures:

- Voltage, 1.6V
- Capacity, 550 mAh => 550/1000 = 0.55 Ah
- Weight, 20 g => 20/1000 = 0.02 Kg
- Volume, 6.4cm3

The second step: trying to find the battery capacity in Watts and Jouels.

- ⇨ Battery capacity in Watts = 1.6x0.55 = 0.88 Wh
- ⇨ Battery capacity in Jouels = 0.88 x 3600 = 3168 J

The Third step: trying to find Volumetric energy density:

- ⇨ Volumen = 6.4 cm^3
- ⇨ Volumetric Energy Density = 3168 / 6.4 = 495 J/cm^3

The Fourth step: trying to find Gravimetric energy density:

- ⇨ Mass = 0.020 Kg
- ⇨ Gravimetric Energy Desnity = 0.88 / 0.02 = 44 Wh/kg

b. Suppose that when connected to an electrical circuit, this battery delivers a current of 0.25A. Calculate the Volumetric and Gravimetric power density in SI units.

The first step: is to find the power in Watts:
Power = voltage x current

- ⇨ Voltage = 1.6 V
- ⇨ Current = 0.25 A
- ⇨ 1.6 x 0.25 = 0.4 W

The second step: is to find the volumetric power density:

- ⇨ Volume = 6.4 cm^3
- ⇨ Power = 0.4 W
- ⇨ $0.4 / 6.4 \times 10^{-6} = 62500\ W/m^3$

The Third step: is to find the gravimetric power density:

- ⇨ Mass = 0.02 Kg
- ⇨ Power = 0.4 W
- ⇨ 0.4 / 0.02 = 20 W/Kg

Q72: The batteries that have the property to be rechargeable are called:

a. Primary batteries
b. Primitive batteries
c. Secondary batteries
d. Alkaline batteries
e. Tertiary batteries

Answer: C) secondary batteries

Q73: The amount of energy stored per unit volume is defined as ________________.

a. Volumetric energy density
b. Gravimetric power density
c. Volumetric power density
d. Gravimetric energy density
e. Voltage

Answer: A) Volumetric energy density

Q74: The process that, all batteries lose charge when not in use is called ______________.

a. Shelf life
b. Self discharge
c. Auto destruction
d. Self destruction
e. Auto loss

Answer: b) Self discharge

Q75: Explain briefly how the battery works. Give examples of different batteries.

Answer:

Batteries produce electricity from a chemical reaction, called an electrochemical reaction.

The chemical reaction depends upon the material used to make the anode, the material used to make the cathode and the material used for the electrolyte. The chemistry, as well as the details of the physical construction, determines whether the batteries can be recharged or not.

Examples: lead-acid batteries, alkaline batteries, nickel--cadmium (NiCd), nickelmetal hydride (NiMH), lithium and lithium-ion (Li-ion) batteries.

Q76: Suppose a battery has the following parameters:

- Voltage: 1.2V
- Capacity: 600 mAh
- Weight: 24 g
- Volume: 9 cm^3
- Current delivered: 1A

Calculate the volumetric energy density and the gravimetric power density in SI units.

Answer:

The first step: is converting the measures:

- Voltage: 1.2V
- Capacity: 600 mAh => 600/1000 = 0.6 Ah
- Weight: 24 g => 24 /1000 = 0.024 Kg
- Volume: 9 cm^3 => 9/1000 = 0.009 M^3
- Current delivered: 1A

The Second step: is to find the battery capacity in Watts and Jouels:

The first step: is converting the measures:

- ⇨ Battery capacity in Watts = 1.2 x 0.6 = 0.72 Wh
- ⇨ Battery capacity in Jouels = 0.72 x 3600 = 2592 J

The second step: is to find the volumetric energy density for Joules:

- ⇨ Volume = 0.009 m^3
- ⇨ 2592 / 0.009 = 288000 J/m3

The Third step: is to find the gravimetric power density:

- ⇨ Current delivered = 1A
- ⇨ Power = 1.2 V
- ⇨ 1 A x 1.2 = 1.2 W
- ⇨ Mass = 0.024 Kg
- ⇨ Gravimetric power density = 1.2 / 0.024 = 50 W/Kg

Q76: A 1.2V battery has a capacity of 1700 mAh. How long could it run if the load has a resistance of 50ohm? What energy does the battery store? Give your answer in both watt hours and joules.

Answer:

The first step: to find the current drawn:

- ⇨ 1.2 / 50 ohm = 0.024 A
- ⇨ Converting 0.024 A to measure (mA)
- ⇨ 0.024 x 1000 = 24 mA

The Second step: to find how much hours could it run:

- ⇨ Capacity = 1700 mAh
- ⇨ Current drawn from the battery = 24 mA
- ⇨ Capacity = ixt
- ⇨ 1700 mAh = 24 mA x t
- ⇨ t= 1700 mAh / 24 mA = 71h

The Third step: to find the battery stores in Watts and Jouels:

- ⇨ Capacity = 1700 mAh
- ⇨ Converting 1700 mAh to (Ah) by deviding 1700/1000=1.7 Ah
- ⇨ So, The battery store in watts = 1.2 X 1.7 = 2.04 Wh
- ⇨ So, The battery store in Jouels = 2.04 X 3600 = 7344 J

Q77: The chemical reaction inside a battery depends upon:

a. The material used to make the anode
b. The material used to make the cathode
c. The material used for the electrolyte
d. All of the above
e. None of the above

Answer: d) All of the above

Q78: The following numbers appears on the back of a battery: 1.5 Volts, 12 grams, 10 cm^3, 10 Ohms, 600 mAh.

a. Calculate the volumetric and gravimetric energy density of this battery in SI units.

Answer:

The first step: converting the measures:

- Voltage: 1.5V
- Capacity: 600 mAh => 600/1000 = 0.6 Ah
- Weight: 12 g => 12 /1000 = 0.012 Kg
- Volume: 10 cm^3 => 10/1000 = 0.01 M^3
- Resistance = 10 Ohms

The Second step: to find the battery stores in Watts and Jouels:

- ⇨ Capacity = 1700 mAh => 0.6 Ah
- ⇨ So, The battery store in watts = 1.5 X 0.6 = 0.9 Wh
- ⇨ So, The battery store in Jouels = 0.9 X 3600 = 3240 J

The Third step: to find the Volumetric Energy Density in Joules:

- ⇨ Volumetric = energy / volume
- ⇨ Volume = 0.01 M^3
- ⇨ 3240 / 0.01 = 324000 J/m3

The fourth step: to find the Gravimetric Energy Density in Joules/Kg:

- ⇨ Volumetric = energy / Mass
- ⇨ Mass = 0.012 Kg
- ⇨ 3240 / 0.012 = 270000 J/Kg

B- This battery is connected to a 30 Ohm resistance,

i. What time this battery can last with this load?

Answer:

The first step: to calculate the current i=V/(RL+Ri)

- ⇨ Voltage = 1.5 V
- ⇨ Internal Resistance = 10 ohms
- ⇨ Resistance L = 10 ohms
- ⇨ 1.5 / (10+30) = 0.0375 A
- ⇨ Convert the 0.0375 A into measure (mA)
- ⇨ 0.0375 * 1000 = 37.5 mA
- ⇨ Capacity = ixt
- ⇨ Capacity = 600 mAh
- ⇨ 600 mAh = 37.5 mA x t
- ⇨ t= 600 mAh / 37.5 mA
- ⇨ t= 16 h

ii. ii. Calculate the volumetric and gravimetric power density in SI units.

Answer:

The first step: to find the Volumetric Power Density

- ⇨ Volumetric Power Density = Power / Volume
- ⇨ Power = 1.5
- ⇨ Volume = 0.01 M^3
- ⇨ Current = 37.5 mA
- ⇨ Power of battery in Watts = 1.5 x 37.5 = 56.25 W
- ⇨ V.P.D = 56.25/0.01 = 5625 W/M^3

The Second step: to find the Gravimetric Power Density

- ⇨ Mass = 0.012 Kg
- ⇨ Gravimetric Power Density = 56.25 /0.012 Kg
- ⇨ G.P.D= 4687.5 W/Kg

Q79: A battery has the following characteristics: 1.2V (nominal voltage), 800mAh (Capacity), 24 g (weight), and 8 cm3 (Volume). The gravimetric energy density of this battery is:

a. 40000 J/Kg
b. 144 Wh/Kg
c. 144000 J/Kg
d. 432 J/cm3
e. 432 * 106 J/m3

Answer: c. 144000 J/Kg

Q80: A 1.6V battery has a capacity of 600 mAh. How long could it run if the load has a resistance of 25 ohm?

Answer:

The current drawn from the battery = 1.6 v / 25 ohms = 0.064 A

To convert the 0.064 A to (mA), which,

- ⇨ 0.064 * 1000 = 64 mA
- ⇨ Capacity = ixt
- ⇨ 600 mAh / 64 mA = 9.4 h
- ⇨ So, it could run for 9.4 h

Q81: If the battery voltage is 1.5V volts and the current that flows from the battery is 700 mA, what will the battery resistance R in ohms?

Answer:

- ⇨ Voltage = R x i
- ⇨ Convert the battery capacity 700 mA to A, which,
- ⇨ 700 / 1000 = 0.7 A
- ⇨ 1.5 = R x 0.7
- ⇨ R = 1.5 / 0.7 = 2.4 Ohms

Good Luck,