General

The battery is the primary "source" of electrical energy on Toyota vehicles. It stores chemicals, not electricity. Two different types of lead in an acid mixture react to produce an electrical pressure. This **electrochemical reaction** changes chemical energy to electrical energy.

Battery Functions

1. **ENGINE OFF:** Battery energy is used to operate the lighting and accessory systems.

2. **ENGINE STARTING:** Battery energy is used to operate the starter motor and to provide current for the ignition system during cranking.

3. **ENGINE RUNNING:** Battery energy may be needed when the vehicle's electrical load requirements exceed the supply from the charging system.

In addition, the battery also serves as a **voltage stabilizer**, or large filter, by absorbing abnormal, transient voltages in the vehicle's electrical system. Without this protection, certain electrical or electronic components could be damaged by these high voltages.

Battery Types

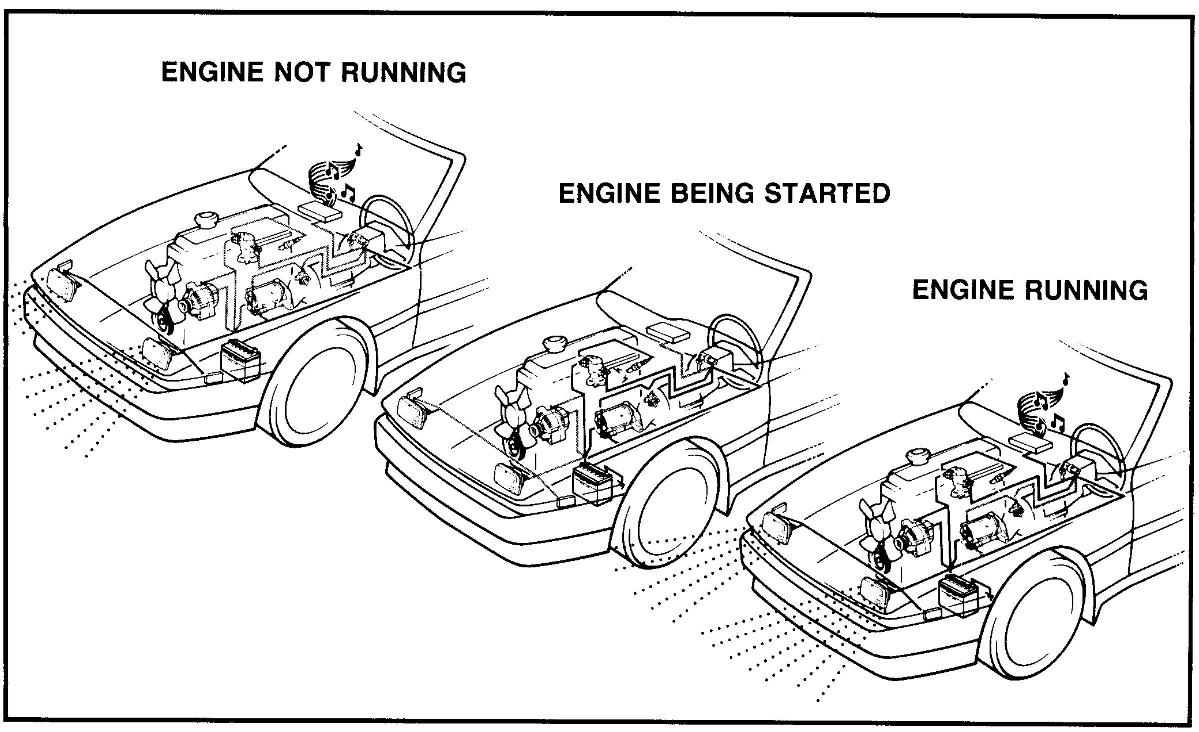
1. **PRIMARY CELL:** The chemical reaction totally destroys one of the metals after a period of time. Small batteries for flashlights and radios are primary cells.

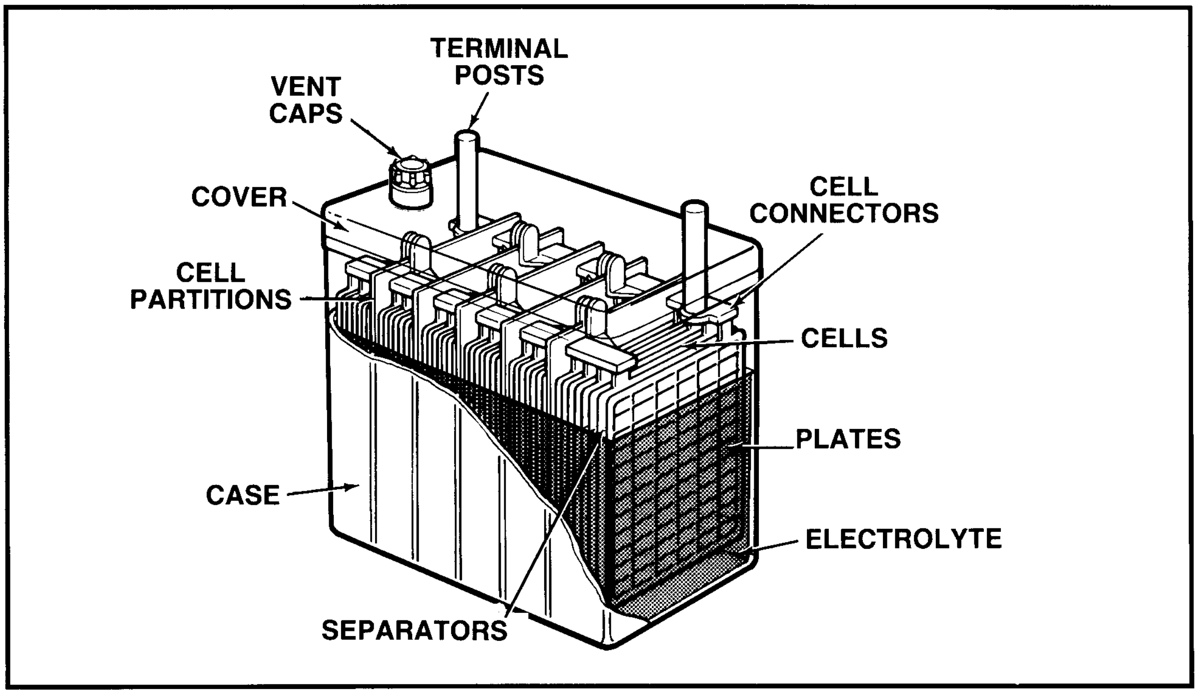
2. **SECONDARY CELLS:** The metals and acid mixture change as the battery supplies voltage. The metals become similar, the acid strength weakens. This is called **discharging**. By applying current to the battery in the opposite direction, the battery materials can be restored. This is called **charging**. Automotive lead-acid batteries are secondary cells.

3. **WET-CHARGED:** The lead-acid battery is filled with electrolyte and charged when it is built. During storage, a slow chemical reaction will cause self-discharge. Periodic charging is required. For Toyota batteries, this is every 5 to 7 months.

4. **DRY-CHARGED:** The battery is built, charged, washed and dried, sealed, and shipped without electrolyte. It can be stored for 12 to .18 months. When put into use, it requires adding electrolyte and charging.

5. **LOW-MAINTENANCE:** Most batteries for Toyota vehicles are considered low-maintenance batteries. Such batteries are built to reduce internal heat and water loss. The addition of water should only be required every 15,000 miles or so.





Construction

1. CASE: Container which holds and protects all battery components and electrolyte, separates cells, and provides space at the bottom for sediment (active materials washed off plates). Translucent plastic cases allow checking electrolyte level without removing vent caps.

2. COVER: Permanently sealed to the top of the case; provides outlets for terminal posts, vent holes for venting of gases and for battery maintenance (checking electrolyte, adding water).

3. PLATES: Positive and negative plates have a grid framework of antimony and lead alloy. Active material is pasted to the grid ... brown-colored lead dioxide (Pb02) on positive plates, gray-colored sponge lead (Pb) on negative plates. The number and size of the plates determine current capability ... batteries with large plates or many plates produce more current than batteries with small plates or few plates.

4. SEPARATORS: Thin, porous insulators (woven glass or plastic envelopes) are placed between positive and negative plates. They allow passage of electrolyte, yet prevent the plates from touching and shorting out.

5. **CELLS:** An assembly of connected positive and negative plates with separators in between is called a cell or element. When immersed in electrolyte, a cell produces about 2.1 volts (regardless of the number or size of plates). Battery cells are connected in series, so the number of cells determines the battery voltage. A "1 2 - volt" battery has six cells.

6. CELL CONNECTORS: Heavy, cast alloy metal straps are welded to the negative terminal of one cell and the positive terminal of the adjoining cell until all six cells are connected in series.

7. CELL PARTITIONS: Part of the case, the partitions separate each cell.

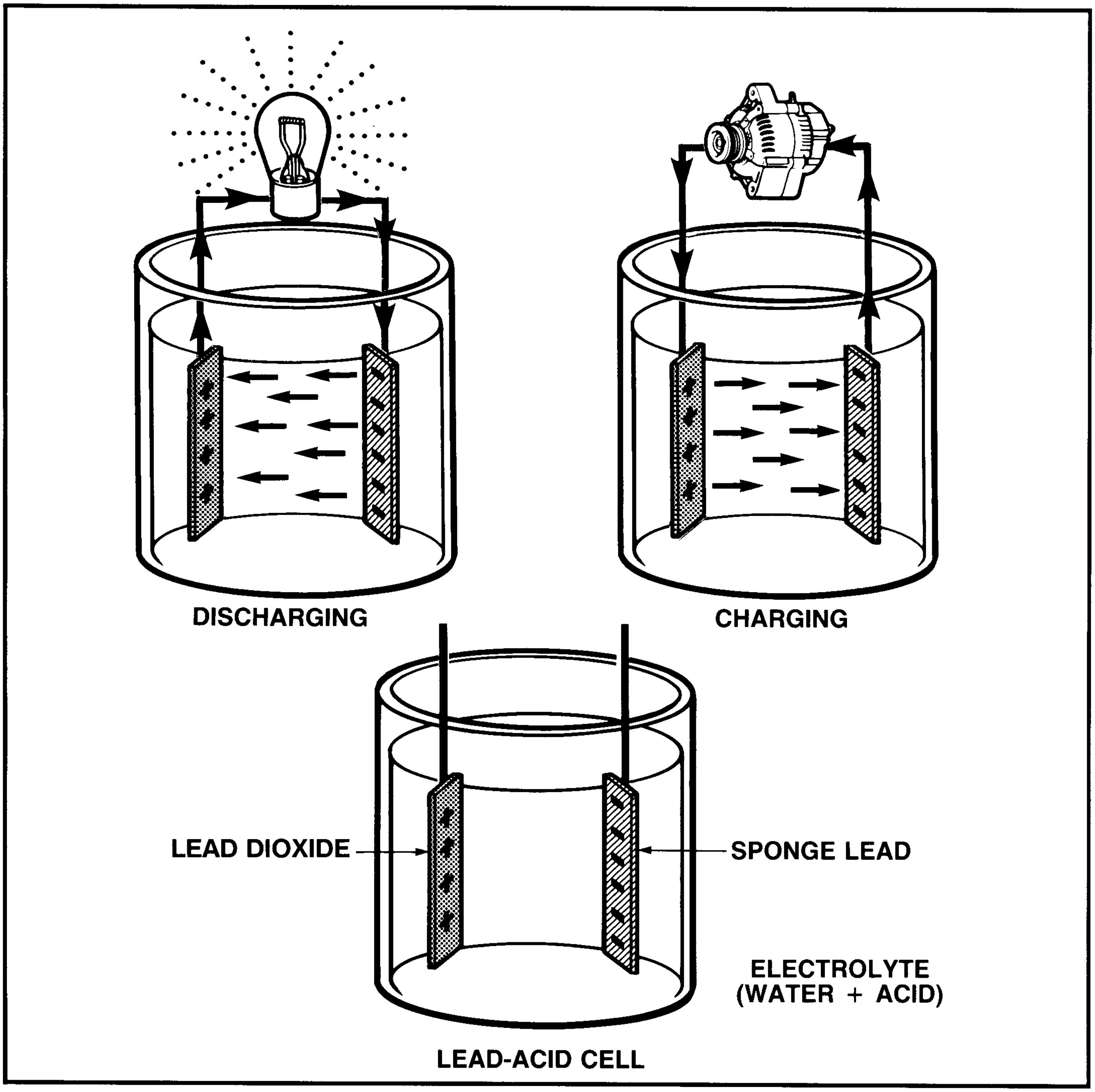
8. TERMINAL POSTS: Positive and negative posts (terminals) on the case top have thick, heavy cables connected to them. These cables connect the battery to the vehicle's electrical system (positive) and to ground (negative).

9. VENT CAPS: Types include individual filler plugs, strip-type, or box-type. They allow controlled release of hydrogen gas during charging (vehicle operation). Removed, they permit checking electrolyte and, if necessary, adding water.

10. ELECTROLYTE: A mixture of sulfuric acid (H2SO4) and water (H2O). It reacts chemically with the active materials in the plates to create an electrical pressure (voltage). And, it conducts the electrical current produced by that pressure from plate to plate. A fully charged battery will have about 36% acid and 64% water.

CELL THEORY

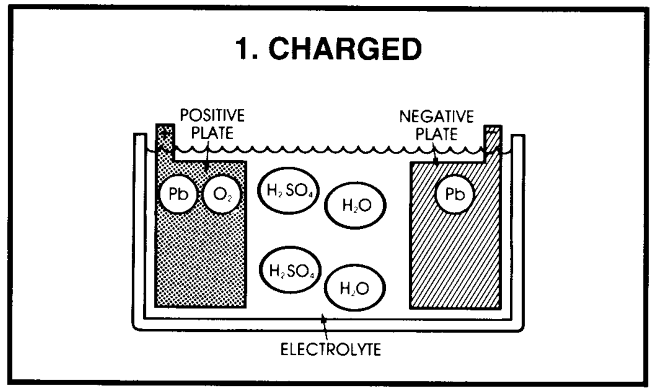
A lead-acid cell works by a simple principle: when two different metals are immersed in an acid solution, a chemical reaction creates an electrical pressure.
One metal is brown-colored lead dioxide (Pb02). It has a positive electrical charge. The other metal is gray colored sponge lead (Pb). It has a negative electrical charge. The acid solution is a mixture of sulfuric acid (H2SO4) and water (H20). It is called electrolyte.
If a conductor and a load are connected between the two metals, current will flow. This **discharging** will continue until the metals become alike and the acid is used up. The action can be reversed by sending current into the cell in the opposite direction. This **charging** will continue until the cell materials are restored to their original condition.



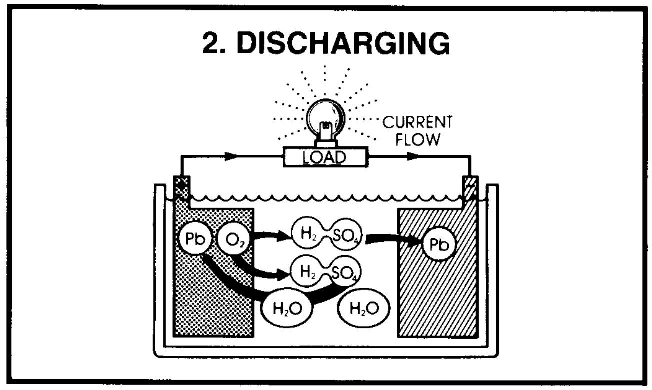
ELECTROCHEMICAL REACTION

A lead-acid storage battery can be partially discharged and recharged many times. There are four stages in this discharging/charging cycle.

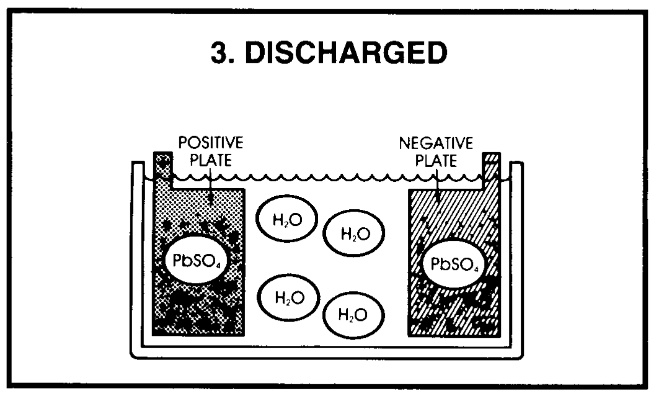
1. CHARGED: A fully charged battery contains a negative plate of sponge lead (Pb), a positive plate of lead dioxide (PbO_2), and electrolyte of sulfuric acid (H_2SO_4) and water (H_2O).



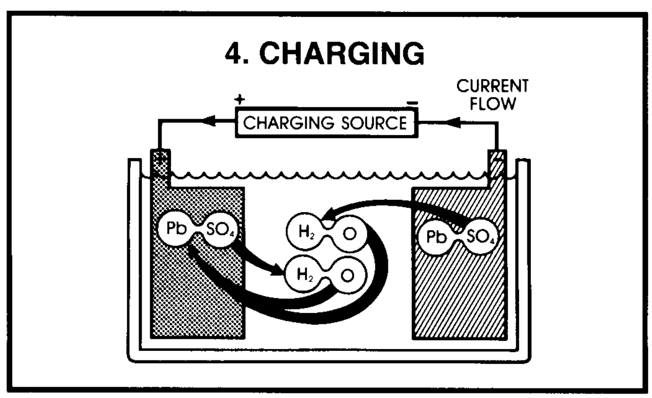
2. DISCHARGING: As the battery is discharging, the electrolyte becomes diluted and the plates become sulfated. The electrolyte divides into hydrogen (H_2) and sulfate(SO_4) . The hydrogen (H_2) combines with oxygen (0) from the positive plate to form more water (H_2O). The sulfate combines with the lead (Pb) in both plates to form lead sulfate ($PbSO_4$)



3. DISCHARGED: In a fully discharged battery, both plates are covered with lead sulfate ($PbSO_4$) and the electrolyte is diluted to mostly water (H_2O).



4. CHARGING: During charging, the chemical action is reversed. Sulfate (SO_4) leaves the plates and combines with hydrogen (H_2) to become sulfuric acid (H_2SO_4). Free oxygen (O_2) combines with lead (Pb) on the positive plate to form lead dioxide (PbO_2). Gassing occurs as the battery nears full charge, and hydrogen bubbles out at the negative plates, oxygen at the positive.



Capacity Ratings

The battery must be capable of cranking the engine and providing adequate reserve capacity. Its capacity is the amount of electrical energy the battery can deliver when fully charged. Capacity is determined by the size and number of plates, the number of cells, and the strength and volume of electrolyte.

The most commonly used ratings are:

- Cold Cranking Amperes (CCA)
- Reserve Capacity (RC)
- Amp-Hours (AH)
- Power (Watts)

COLD-CRANKING AMPERES (CCA)

The battery's primary function is to provide energy to crank the engine during starting. This requires a large discharge in a short time. The **CCA Rating** specifies, in amperes, the discharge load a fully charged battery at 0˚F (-1 7.8˚C) can deliver for 30 seconds while maintaining a voltage of at least 1.2 volts per cell (7.2 volts total for a 12-volt battery). Batteries used on various Toyota vehicles have CCA ratings ranging from 350 to 560 amps.

RESERVE CAPACITY (RC)

The battery must provide emergency energy for ignition, lights, and accessories if the vehicle's charging system fails. This requires adequate capacity at normal temperatures for a certain amount of time. The **RC Rating** specifies, in minutes, the length of time a fully charged battery at 80˚F (26.7'C) can be discharged at 25 amps while maintaining a voltage of at least 1.75 volts per cell (10.5 volts total for a 12-volt battery). Batteries used on various Toyota vehicles have RC ratings ranging from 55 to 115 minutes.

AMP-HOURS (AH)

The battery must maintain active materials on its plates and adequate lasting power under light-load conditions. This method of rating batteries is also called the 20-hour discharge rating. Original equipment batteries are rated in amp-hours. The ratings of these batteries are listed in the parts microfiche. The **Amp-Hour Rating** specifies, in amphours, the current the battery can provide for 20 hours at 80˚F (26.7˚C) while maintaining a voltage of at least 1.75 volts per cell (10.5 volts total for a 12-volt battery). For example, a battery that can deliver 4 amps for 20 hours is rated at 80 amp-hours (4 x 20 = 80). Batteries used on various Toyota vehicles have AH ratings ranging from 40 to 80 amp-hours.

POWER (WATTS)

The battery's available cranking power may also be measured in watts. The **Power Rating**, in watts, is determined by multiplying the current available by the battery voltage at 0˚F (-1 7.8˚C). Batteries used on various Toyota vehicles have power ratings ranging from 2000 to 4000 watts.

TYPICAL TOYOTA ORIGINAL-EQUIPMENT BATTERIES

Battery	Rating
50 D 20	50 Amp-Hours
55 D 23	60 Amp-Hours
N 70 Z	70 Amp-Hours

REPLACEMENT BATTERIES USED ON TOYOTA VEHICLES

BCI GROUP* (DIMENSIONS)	TYPE (MONTHS)	PLATES (NUMBER)	RATINGS	
			CCA (AMPERES)	RC (MINUTES)
24, 24F (10-3/16L × 6-3/16W × 9H)	24	48	350	55
	36	54	400	60
	48	72	525	100
27, 27F (12L × 6-3/16W × 8-15/16H)	48	84	560	115

FACTORS AFFECTING CHARGING

Five factors affect battery charging by increasing its internal resistance and CEMF (counter-electromotive force produced by the electrochemical reaction):

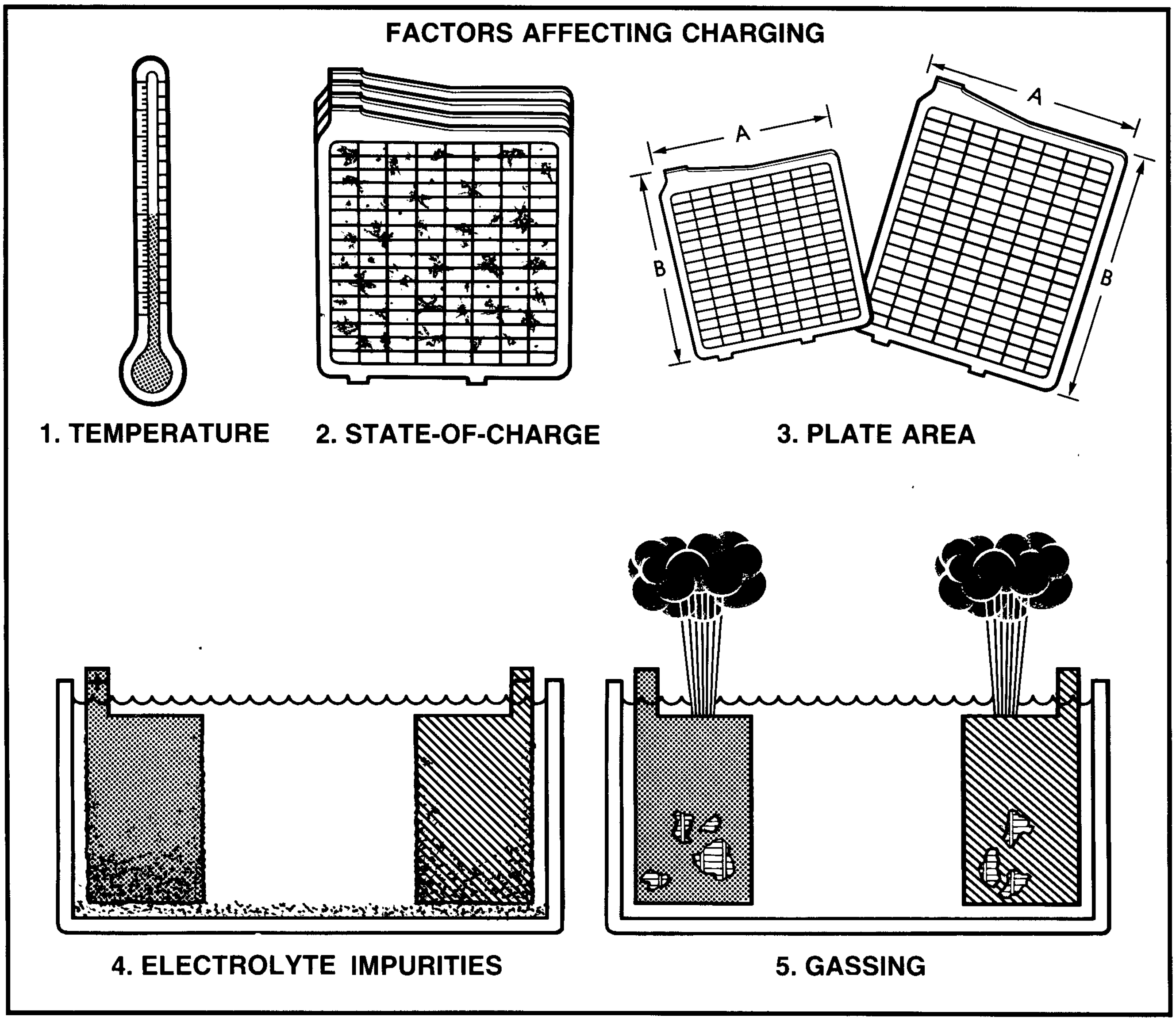
1. TEMPERATURE: As the temperature decreases the electrolyte resists charging. A cold battery will take more time to charge; a warm battery, less time. Never attempt to charge a frozen battery.

2. STATE-OF-CHARGE: The condition of the battery's active materials will affect charging. A battery that is severely discharged will have hard sulfate crystals on its plates. The vehicle's charging system may charge at too high of a rate to remove such sulfates.

3. PLATE AREA: Small plates are charged faster than large plates. When sulfation covers most of the plate area, the charging system may not be able to restore the battery.

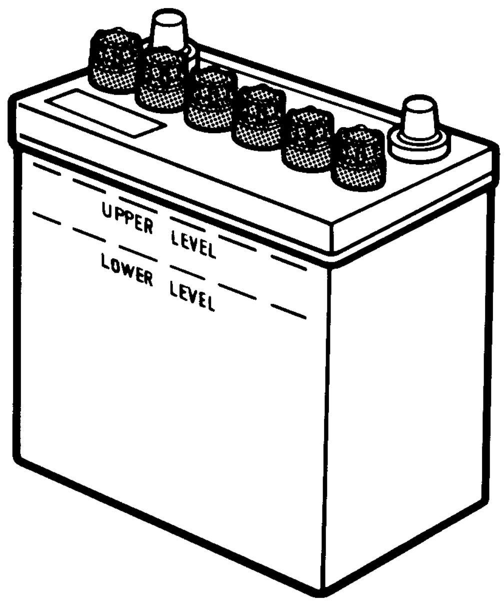
4. IMPURITIES: Dirt and other impurities in the electrolyte increase charging difficulty.

5. GASSING: Hydrogen and oxygen bubbles form at the plates during charging. As these bubble out, they wash away active material, cause water loss, and increase charging difficulty.



Causes of Battery Failure

All batteries have a limited life, but some conditions can shorten that life.



ELECTROLYTE LEVEL: A low electrolyte level exposes active material, and any sulfate hardens and resists chemical action. Loss of electrolyte may be caused by a cracked case, poor maintenance (not adding water when needed), or severe overcharging which causes high internal heat and excessive gassing. Too much electrolyte is just as bad. Overfilling dilutes the electrolyte and spillage may corrode battery terminals.

CORROSION: Spilled electrolyte and condensation from gassing may cause corrosion on terminals, connectors, and metal holddowns/carriers. Such corrosion increases electrical resistance, which reduces available voltage and charging effectiveness. It may also create a current leakage path to allow self-discharge.

CYCLING: Repeated cycling – from fully charged to fully discharged and back – may cause loss of active material from the positive plates. This reduces battery capacity and its useful life.

OVERCHARGING: Overcharging by the vehicle's charging system or separate battery charger causes excessive gassing and high internal heat. Too much gassing can wash active materials off the plates, as well as cause excessive water usage. Too much heat can oxidize the positive plate material and warp the plates.

UNDERCHARGING: A faulty charging system will not maintain the battery at full charge. Severe undercharging allows sulfate on the plates to become hard and impossible to remove by normal charging. The weak electrolyte freezes easier. The undercharged battery may fail to crank the engine.

TEMPERATURE: High temperatures from overcharging or engine heat can shorten battery life. Low temperatures can cause freezing of weak electrolyte. At 0°F (-17.8°C), a fully charged battery provides less than half its normal power. At the same time, the cold engine requires twice as much cranking power as it does with normal temperatures. The electrolyte in a fully charged battery will not freeze until -60°F or lower, while the electrolyte in a fully discharged battery will freeze at +18°F.

VIBRATION: A battery must be mounted securely. Vibration can loosen connections, crack the case, and damage internal components.

Diagnosis and Testing

All batteries require routine maintenance to identify and correct problems caused by physical abuse and low electrolyte levels. A **visual inspection** can identify such physical problems. A **state-of-charge test** checks the electrolyte strength. And, electrical testing identifies overcharging or undercharging problems. These tests include a capacity, or heavy-load, test.

SAFETY FIRST!

When testing or servicing a battery, safety should be your first consideration. The electrolyte contains sulfuric acid. It can eat your clothes. It can burn your skin. It can blind you if it gets in your eyes. It can also ruin a car's finish or upholstery. If electrolyte is splashed on your skin or in your eyes, wash it away immediately with large amounts of water. If electrolyte is spilled on the car, wash it away with a solution of baking soda and water.

When a battery is being charged, either by the charging system or by a separate charger, gassing will occur. Hydrogen gas is explosive. Any flame or spark can ignite it. If the flame travels into the cells, the battery may explode.

Safety precautions include:

- Wear gloves and safety glasses.
- Remove rings, watches, other jewelry.
- Never use spark-producing tools near a battery.
- Never lay tools on the battery.
- When removing cables, always remove the ground cable first.
- When connecting cables, always connect the ground cable last.
- Do not use the battery ground terminal when checking for ignition spark.
- Be careful not to get electrolyte in your eyes or on your skin, the car finish, or your clothing.
- If you have to mix battery electrolyte, pour the acid into the water - not the water into the acid.
- Always follow the recommended procedures for battery testing and charging and for jump starting an engine.

CARE OF ELECTRONICS

Disconnecting the battery will erase the memory on electronic devices. Write down trouble codes and programmed settings before disconnecting the battery.

Also, to prevent damage to electronic components:

- Never disconnect the battery with the ignition ON.
- Never use an electric welder without the battery cables disconnected.
- Never reverse battery polarity.

VISUAL INSPECTION

Battery service should begin with a thorough visual inspection. This may reveal simple, easily corrected problems, or problems that might require battery replacement.

1 . Check for cracks in the battery case and for broken terminals. Either may allow electrolyte leakage. The battery must be replaced.

2. Check for cracked or broken cables or connections. Replace, as needed.

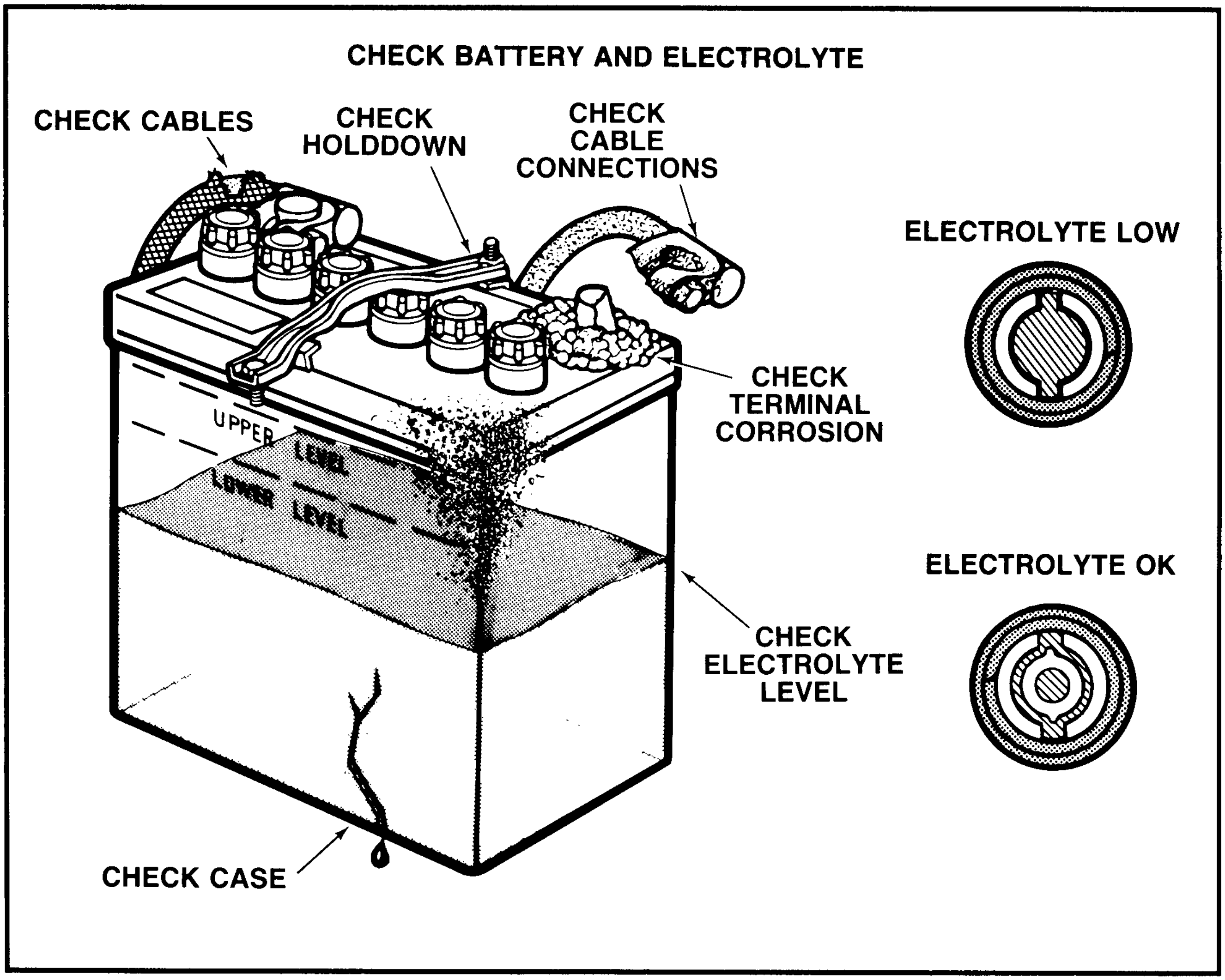
3. Check for corrosion on terminals and dirt or acid on the case top. Clean the terminals and case top with a mixture of water and baking soda or ammonia. A wire brush is needed for heavy corrosion on the terminals.

4. Check for a loose battery hold-down and loose cable connections. Tighten, as needed.

5. Check the level of electrolyte. The level can be viewed through the translucent plastic case or by removing the vent caps and looking directly into each cell. The proper level is 1/2" above the separators. If necessary, add distilled water to each low cell. Avoid overfilling. When water is added, always charge the battery to make sure the water and acid mix.

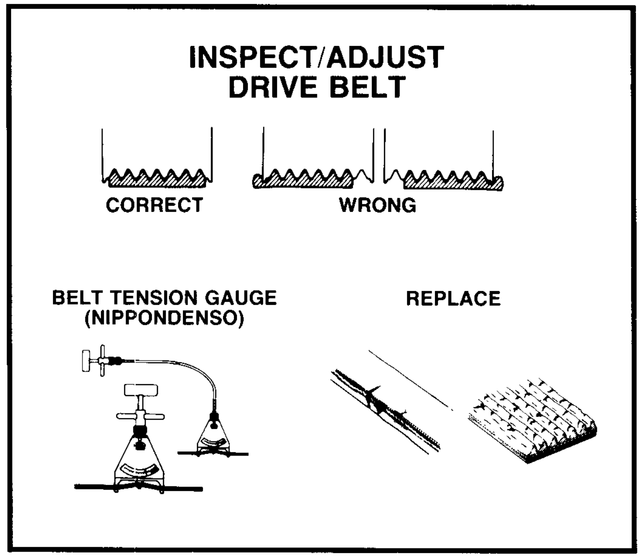
6. Check for cloudy or discolored electrolyte caused by overcharging or vibration. This could cause high self discharge. The problem should be corrected and the battery replaced.

7. Check the condition of plates and separators. Plates should alternate dark (+) and light (-). If all are light, severe undercharging is indicated. Cracked separators may allow shorts. The battery should be replaced. An undercharging problem should be corrected.



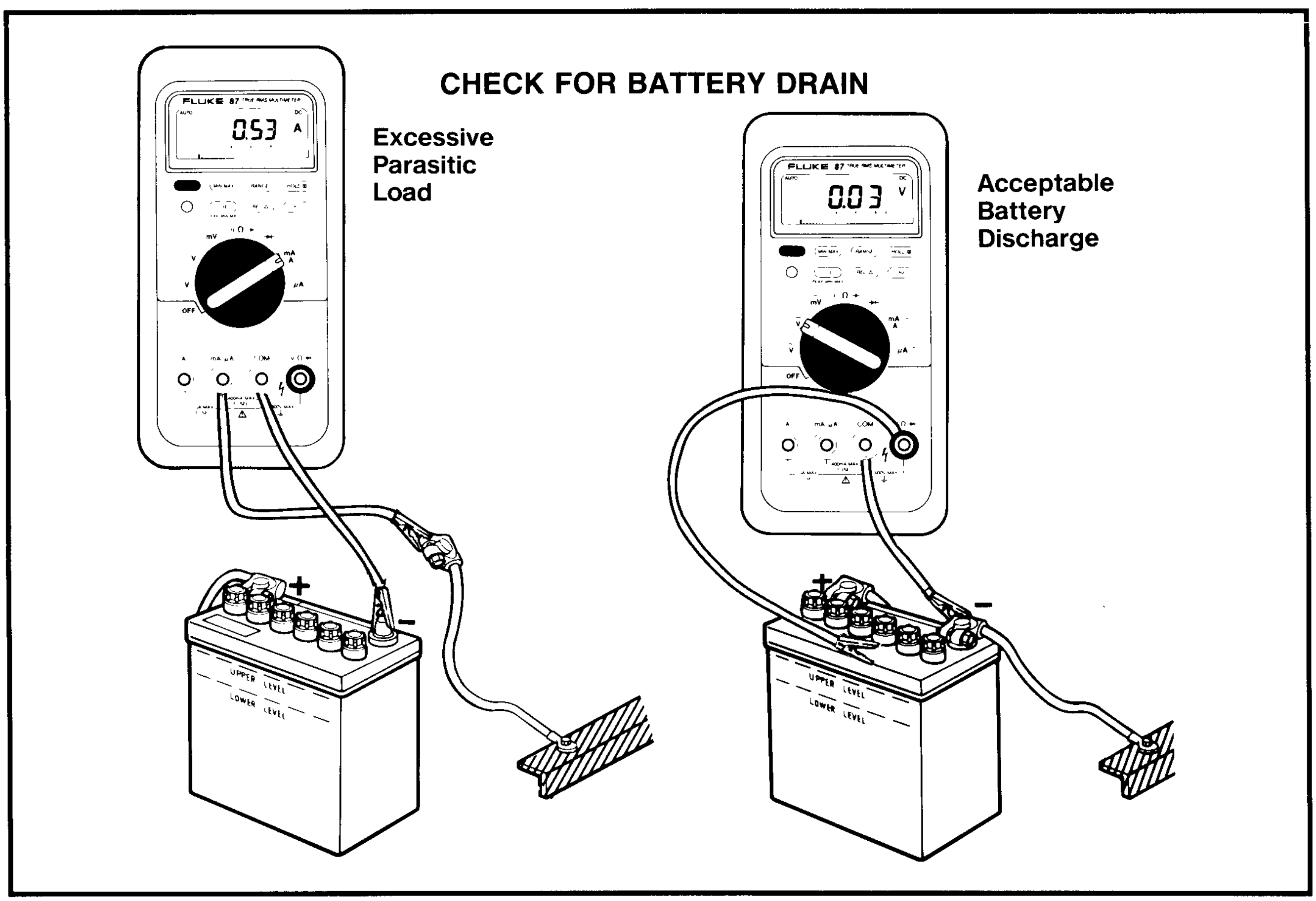
8. Check the tension and condition of the alternator drive belt. A loose belt must be tightened. It will prevent proper charging. A belt too tight will reduce alternator life. It should be loosened to specs. A frayed or glazed belt will fail during operation. Replace it.

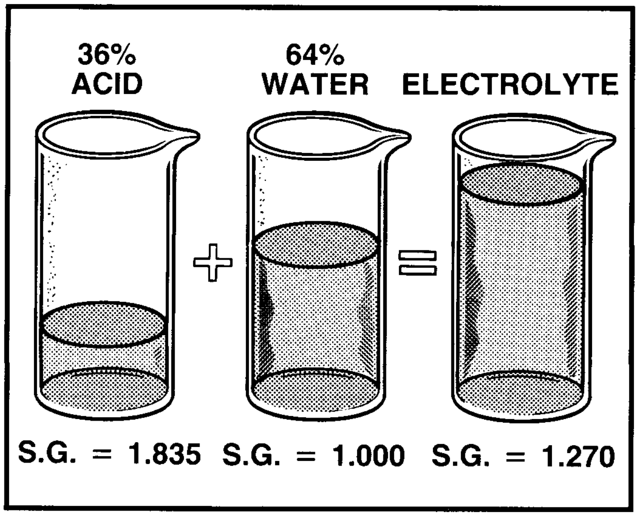
NOTE: Approved Equipment tension gauge: Nippondenso, BTG-20 (SST) Borroughs BT-33-73F

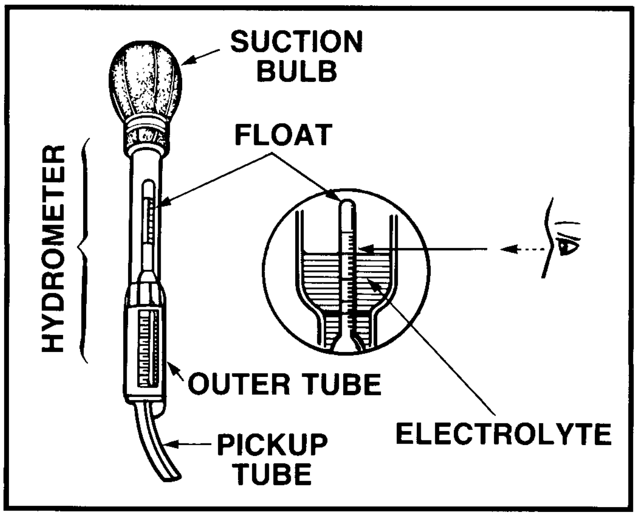


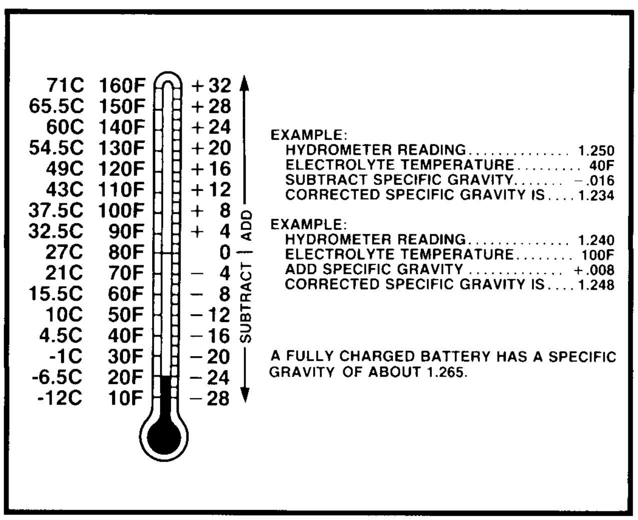
9. Check for **battery drain** or **parasitic loads** using an ammeter. Connect the ammeter in series between the battery negative terminal and ground cable connector. Toyota vehicles typically show less than .020 amp of current to maintain electronic memories ... a reading of more than .035 amp is unacceptable. If the ammeter reads more than .035 amp, locate and correct the cause of excessive battery drain.

10. Check for battery discharge across the top of the battery using a voltmeter. Select the low voltage scale on the meter, connect the negative (black) test lead to the battery's negative post, and connect the positive (red) test lead to the top of the battery case. If the meter reading is more than 0.5 volt, clean the case top using a solution of baking soda and water.









STATE-OF-CHARGE TEST

The state-of-charge test checks the battery's chemical condition. One method uses a hydrometer to measure the specific gravity of the electrolyte. Another method uses a digital voltmeter to check the battery's open circuit voltage and, for a general indication of the battery's condition, check the indicator eye (if the battery has one) or check the headlamp brightness during starting.

Specific Gravity

Specific gravity means exact weight. The hydrometer compares the exact weight of electrolyte with that of water. **Strong electrolyte in a charged battery is heavier than weak electrolyte in a discharged battery.**

By weight, the electrolyte in a fully charged battery is about 36% acid and 64% water. The specific gravity of water is 1.000. The acid is 1.835 times heavier than water, so its specific gravity is 1.835. The electrolyte mixture of water and acid has a specific gravity of 1.270 is usually stated as "twelve and seventy."

By measuring the specific gravity of the electrolyte, you can tell if the battery is fully charged, requires charging, or must be replaced. It can tell you if the battery is charged enough for the capacity, or heavy-load test.

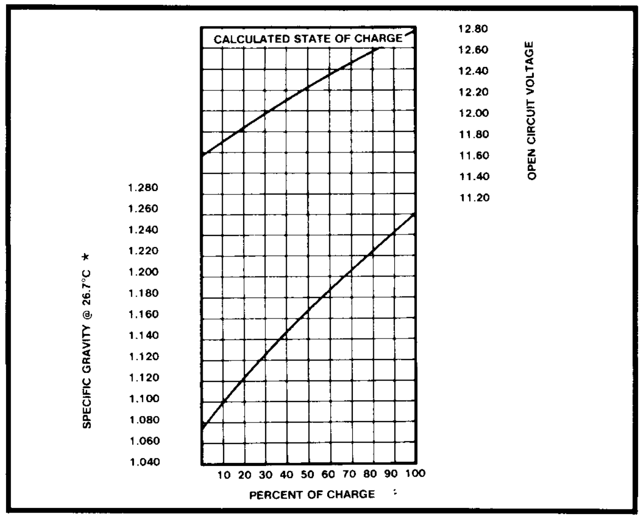
TEST PROCEDURE: The following steps outline a typical procedure for performing a state-of-charge test:

1 . Remove vent caps or covers from the battery cells.
2. Squeeze the hydrometer bulb and insert the pickup tube into the cell closest to the battery's positive (+) terminal.
3. Slowly release the bulb to draw in only enough electrolyte to cause the float to rise. Do not remove the tube from the cell.
4. Read the specific gravity indicated on the float. Be sure the float is drifting free, not in contact with the sides of top of the barrel. Bend down to read the hydrometer a eye level. Disregard the slight curvature of liquid on the float.
5. Read the temperature of the electrolyte.
6. Record your readings and repeat the procedure for the remaining cells.

TEMPERATURE CORRECTION: The specific gravity changes with temperature. Heat thins the liquid, and lowers the specific gravity. Cold thickens the liquid, and raises the specific gravity. Hydrometers are accurate at 80-F (26.7˚C). If the electrolyte is at any other temperature, the hydrometer readings must be adjusted. Most hydrometers have a built-in thermometer and conversion chart. Refer to the temperature correction chart. For each 1 O˚F (5.5˚C) above 80˚F (26.7˚C), ADD 0.004 to your reading.

TEST RESULTS: Specific gravity readings tell a lot about battery condition.

1. A fully charged battery will have specific gravity readings around 1.265.
2. Specific gravity readings below 1.225 usually mean the battery is run down and must be charged.
3. Readings around 1.190 indicate that sulfation is about to begin. The battery must be charged.
4. Readings of 1.155 indicate severe discharge. Slow charging is required to restore active materials.
5. Readings of 1.120 or less indicate that the battery is completely discharged. It may require replacement, but slow charging may restore some batteries in this condition.
6. A difference of 50 points (0.050) or more between one or more cells indicates a defective battery. It should be replaced.
7. When the specific gravity of all cells is above 1.225 and the variation between cells is less than 50 points, the battery can be tested under load.

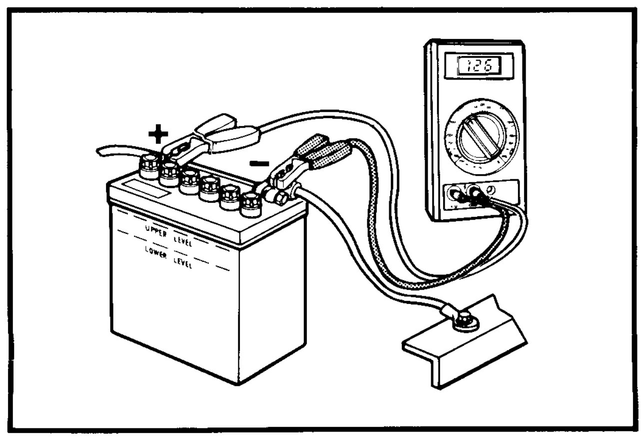


*Difference between cells should not vary more than 50 points (0.050). If it does, replace the battery.

Open-Circuit Voltage

An accurate digital voltmeter is used to check the battery's open-circuit voltage:

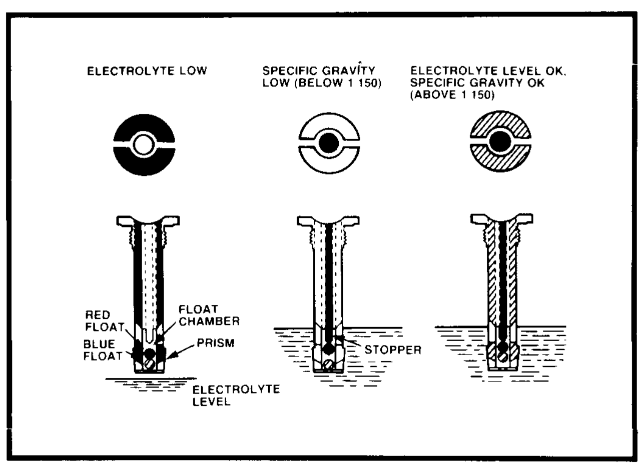
1 . If the battery has just been charged, turn on the headlamps for one minute to remove any surface charge.
2. Turn headlamps off and connect the voltmeter across the battery terminals.
3. Read the voltmeter. A fully charged battery will have an open-circuit voltage of at least 12.6 volts. A dead battery will have an open-circuit voltage of less than 12.0 volts.



Indicator Eye

Toyota original-equipment batteries have an indicator eye for electrolyte level and specific gravity. If the eye shows red, the electrolyte level is low or the battery is severely discharged. If some blue is showing, the level is okay and the battery is at least 25% charged.

NOTE: **The indicator eye should be used only as a** general indication of electrolyte level and strength.



HEAVY-LOAD TEST

While an open circuit voltage test determines the battery's state of charge, it does not measure the battery's ability to deliver adequate cranking power. A **capacity**, or **heavy-load**, test does. A Sun VAT-40 tester is used. If another type of tester is used, follow the manufacturer's recommended procedure.

The following steps outline a typical procedure for load testing a battery:

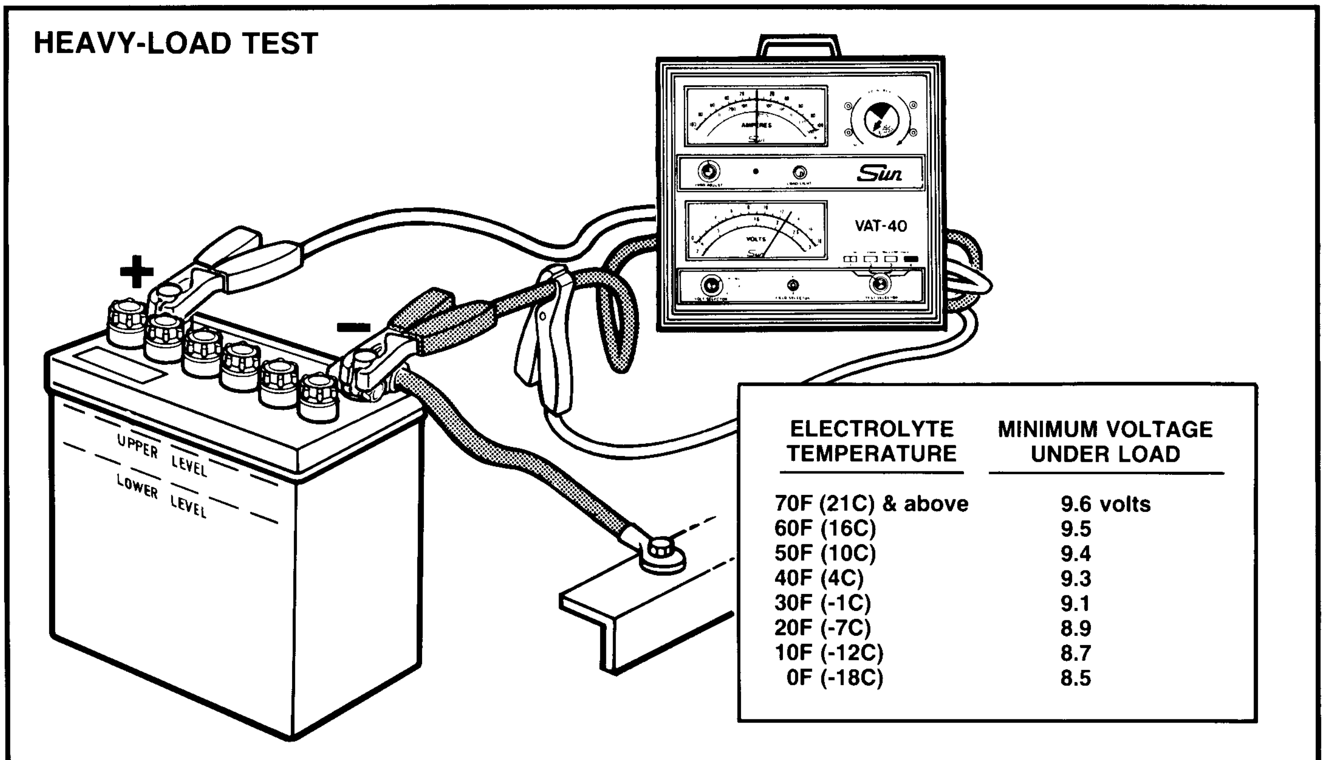
1. Test the open circuit voltage. The battery must be at least half charged. If the open circuit voltage is less than 12.4v, charge the battery.
2. Disconnect the battery cables, **ground cable first**.
3. Prepare the tester:
   - Rotate the Load Increase control to OFF.
   - Check each meter's mechanical zero. Adjust, if necessary.
   - Connect the tester Load Leads to the battery terminals; RED to positive, BLACK to negative.
   - Set Volt Selector to INT 18V. Tester voltmeter should indicate battery open-circuit voltage.

NOTE: Battery open-circuit voltage should be at least 12.4 volts (75% charged). If not, the battery requires charging.

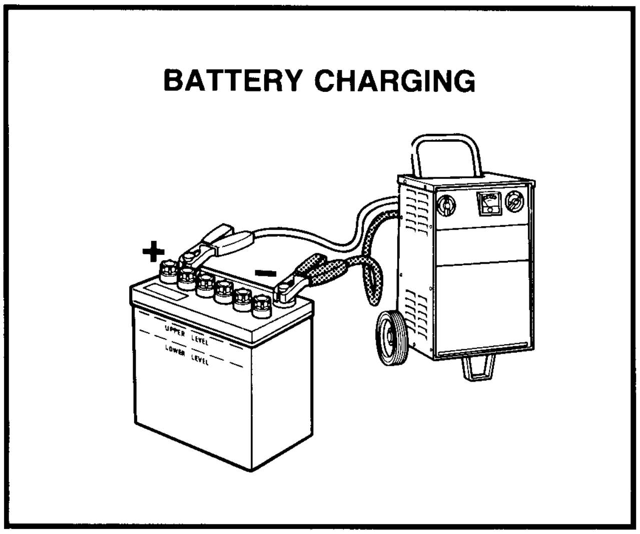
   - Set Test Selector to #2 CHARGING.
   - Adjust ammeter to read ZERO using the electrical Zero Adjust control.
4. Connect the clamp-on Amps Pickup around either tester load cable (disregard polarity).
5. Set the Test Selector Switch to #1 STARTING.
6. Load the battery by turning the Load Increase control until the ammeter reads **3 times the amp-hour (AH) rating or one-half the cold-cranking ampere (CCA) rating.**
7. Maintain the load for **no more than 15 seconds** and note the voltmeter reading.
8. Immediately turn the Load Increase control OFF.
9. If the voltmeter reading was 10.0 volts or more, the battery is good. If the reading is 9.6 to 9.9 volts, the battery is serviceable, but requires further testing. Charge and re-test. If the reading was **below 9.6 volts, the battery is either discharged or defective.**

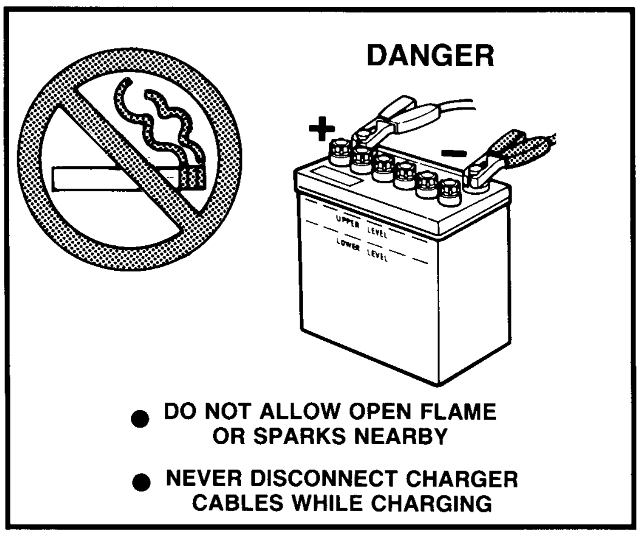
NOTE: Test results will vary with temperature. Low temperatures will reduce the reading. The battery should be at operating temperature.

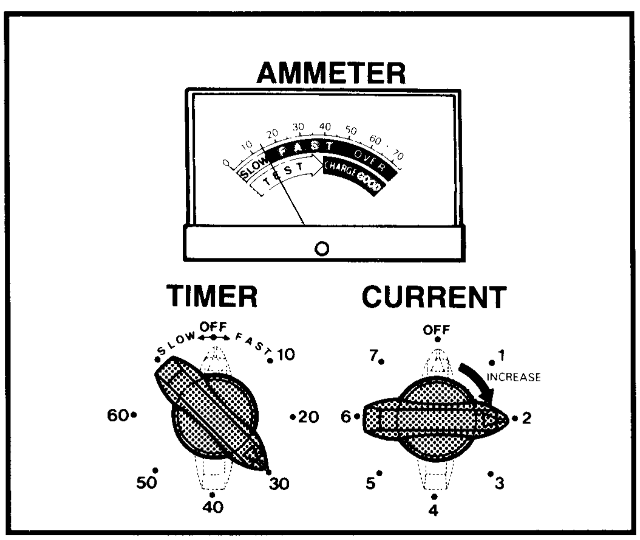
HEAVY-LOAD TEST



ELECTROLYTE TEMPERATURE	MINIMUM VOLTAGE UNDER LOAD
70F (21C) & above	9.6 volts
60F (16C)	9.5
50F (10C)	9.4
40F (4C)	9.3
30F (-1C)	9.1
20F (-7C)	8.9
10F (-12C)	8.7
0F (-18C)	8.5







Battery Service

Battery service procedures include charging, cleaning, jump starting, and replacement. Follow the recommended procedures.

CHARGING

A battery in good condition may occasionally fail to crank the engine fast enough to make it start. In such cases, the battery may require charging.

All battery chargers operate on the same principle: an electric current is applied to the battery to reverse the chemical action in the cells. Never connect or disconnect leads with the charger turned ON. Follow the battery charger manufacturer's instructions. And, do not attempt to charge a battery with frozen electrolyte.

When using a battery charger, always disconnect the battery ground cable first. This will minimize the possibility of damage to the alternator or to electronic components. Otherwise, use a charger with polarity protection that prevents reverse charging.

The battery can be considered fully charged when all cells are gassing freely and when there is no change in specific gravity readings for more than one hour.

Fast Charging

Fast charging is used to charge the battery for a short period of time with a high rate of current. Fast charging may shorten battery life. If time allows, **slow charging is preferred**. Some low maintenance batteries **cannot** be fast charged.

1. Preparation for charging.
   - Clean dirt, dust, or corrosion off the battery; if necessary, clean the terminals.
   - Check the electrolyte level and add distilled water if needed.
   - If the battery is to be charged while on the vehicle, be sure to disconnect both (-) (+) terminals.

2. Determine the charging current and time for fast charging.
   - Some chargers have a test device for determining the charging current and required time.
   - If the charger does not have a test device, refer to the chart below to determine current and time.

3. Using the charger:
   - Make sure that the main switch and timer switch are OFF and the current adjust switch is at the minimum position.
   - Connect the positive lead of the charger to the battery positive terminal (+) and the negative lead of the charger to the battery negative terminal (-).
   - Connect the charger's power cable to the electric outlet.
   - Set the voltage switch to the correct battery voltage.
   - Set the main switch at ON.
   - Set the timer to the desired time and adjust the charging current to the predetermined amperage.

4. After the timer is "off," check the charged condition using a voltmeter.
   - Correct Voltage: 12.6 volts or higher.

If the voltage does not increase, or if gas is not emitted no matter how long the battery is charged, there may be a problem with the battery, such as an internal short.

5. When the voltage reaches the proper reading:
   - Set the current adjust switch to minimum.
   - Turn off the main switch of the charger.
   - Disconnect the charger cables from the battery terminals.
   - Wash the battery case to clean off the acid emitted.

Slow Charging

High charging rates are not good for completely charging a battery. To completely charge a battery, slow charging with a low current is required.
Slow charging procedures are the same as those for fast charging, except for the following:

1. The maximum charging current should be less than 1 1/10th of the battery capacity. For instance, a 40 AH battery should be slow charged at 4 amps or less.

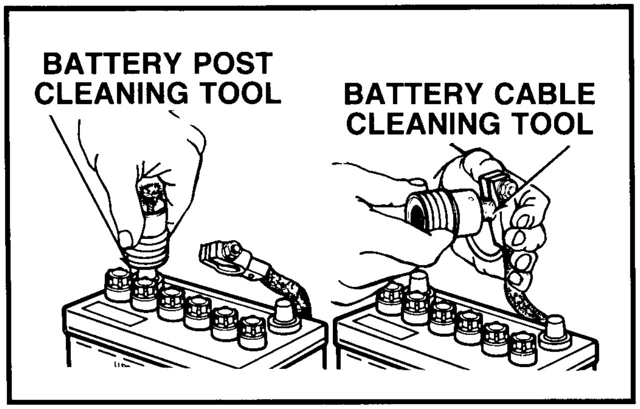
2. Set the charger switch to the slow position (if provided).

3. Readjust the current control switch from time to time while charging.

4. As the battery gets near full charge, hydrogen gas is emitted. When there is no further rise in battery voltage for more than one hour, the battery is completely charged.
   - Battery Voltage: 12.6 volts or higher

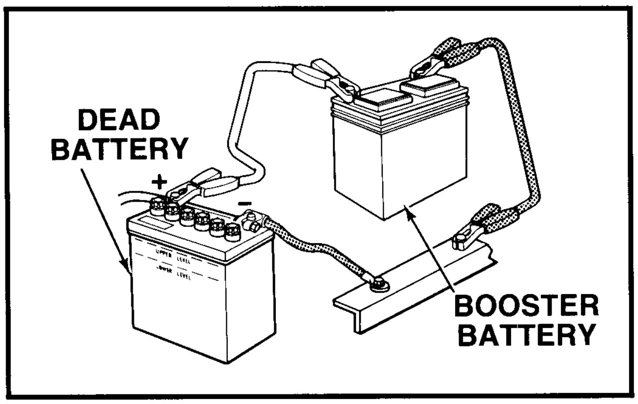
TYPICAL CHARGING RATES FOR FULLY DISCHARGED BATTERIES

Reserve Capacity Rating	20-Hour Rating	5 Amperes	10 Amperes	20 Amperes	30 Amperes	40 Amperes
75 Minutes or less	50 Ampere-Hours or less	10 Hours	5 Hours	2½ Hours	2 Hours	
Above 75 To 115 Minutes	Above 50 To 75 Ampere-Hours	15 Hours	7½ Hours	3¼ Hours	2½ Hours	2 Hours
Above 115 To 160 Minutes	Above 75 To 100 Ampere-Hours	20 Hours	10 Hours	5 Hours	3 Hours	2½ Hours
Above 160 To 245 Minutes	Above 100 To 150 Ampere-Hours	30 Hours	15 Hours	7½ Hours	5 Hours	3½ Hours



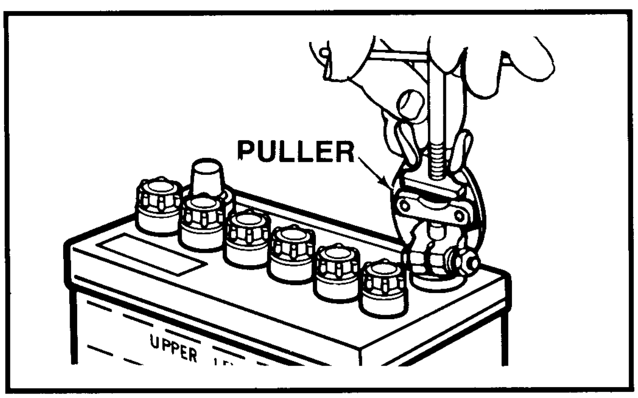
CLEANING

Cleaning the battery will aid your visual inspection and reduce the possibility of current leakage. The battery case can be cleaned with a brush and diluted ammonia or soda solution. Avoid getting the solution in the cells. The battery terminals and cable connections can be cleaned with the cleaning tool (brush) made for that purpose. Remove all corrosion and oxidation, both common causes of high resistance.



JUMP STARTING

When jump starting a dead battery with a booster battery, proper connections prevent sparks. First, connect the two positive terminals. Then, connect one end of the jumper cable to the negative terminal of the booster battery. And, connect the other end to a good ground away from the dead battery. If a spark occurs, it won't be near the battery.



BATTERY REPLACEMENT

If a battery requires replacement: use a cable puller to remove terminal clamps; unfasten the battery hold-down; lift the battery from its carrier with the proper tool; wash and paint corroded parts; replace any damaged parts of the hold-down, support tray, or cables; and select and install a battery of the proper size and capacity rating.

Taken with permission from the Toyota Basic Electrical Course #622,

SELF TEST

This brief self-test will help you measure your understanding of The Battery. The style is the same as that used for A.S.E. certification tests. The answers to this self test are shown on next page.

1. The amount of current a battery can produce is controlled by the:

   A. plate thickness
   B. plate surface area
   C. strength of acid
   D. discharge of load

2. How many volts are produced in each cell of a battery?

   A. 2.1
   B. 6. 0
   C. 9.6
   D. 12.0

3. The plates of a discharged battery are:

   A. two similar metals in the presence of an electrolyte
   B. two similar metals in the presence of water
   C. two dissimilar metals in the presence of an electrolyte
   D. two dissimilar metals in the presence of water

4. A battery's reserve capacity is measured in:

   A. amperes
   B. wafts
   C. amp-Hours
   D. minutes

5. Severe battery undercharging is indicated if:

   A. active materials are washed off the plates
   B. the terminals are corroded
   C. the plates (+ and -) are both very light colored
   D. the electrolyte is cloudy

6. To check for battery drain, you would connect an ammeter between the:

   A. battery and alternator
   B. battery and (-) terminals
   C. battery terminal and ground cable
   D. battery terminal and ground cable

7. What is the state of charge of a battery that has a specific gravity of 1.190 at 80˚F (26.7'C)?

   A. Completely discharged
   B. About 1/2 charged
   C. About 3/4 charged
   D. Fully charged

8. A battery heavy-load test discharges the battery for:

   A. 5 seconds
   B. 10 seconds
   C. 15 seconds
   D. 20 seconds

9. When performing a battery capacity test on a 12-volt battery, the voltage should not fall below:

   A. 12.0 volts
   B. 10.6 volts
   C. 9.6 volts
   D. 8.6 volts

10. The preferred method of recharging a "dead" battery is:

    A. fast charging
    B. slow charging
    C. cycling the battery
    D. with a VAT-40

SELF-TEST ANSWERS

For the preceding self-test on The Battery, the following best complete the sentence or answer the question. In cases where you may disagree with the choice - or may simply want to reinforce your understanding - please review the appropriate workbook page or pages noted.

1 . "B" - The number and size of the plates determine current capability. (Page 2.)

2. "A" - When immersed in electrolyte, a cell produces about 2.1 volts (regardless of the number of size of plates). (Page 2.)

3. "B" - In a fully discharged battery, both plates are covered with lead sulfate and the electrolyte is diluted to mostly water. (Page 4.)

4. "D" - The Reserve Capacity rating is the length of time, in minutes, a fully charged battery at 80'F (26.70C) can be discharged at 25 amps while maintaining a voltage of at least 1.75 volts per cell. (Page 5.)

5. "C" - Plates should alternate dark (+) and light It all are light, severe undercharging is indicated. (Page 9.)

6. "D" - Check for battery drain using an ammeter between the battery negative terminal and ground cable connector. (Page 10.)

7. "B" - Specific gravity readings around 1.190 indicate that sulfation is about to begin. The battery is about 50% charged, and requires charging. (Page 12.)

8. "C" - In a battery load test, maintain the load for no more than 15 seconds and note the voltmeter reading. (Page 13.)

9. "C" - In a battery capacity or heavy-load test, if the voltmeter reading falls below 9.6 volts, the battery is either discharged or defective. (Page 13.)

10. "B" - Slow charging is preferred. (Page 15.)

ASSIGNMENT ***NAME:***________________________________

1. Describe the basic construction of a lead-acid battery.
2. Explain what materials are used to make up the: positive plate, negative plate, and electrolyte.
3. Describe the basic chemical operation of a single cell that makes a battery.
4. List the voltage output of both a single battery cell and a six cell automotive battery. Be exact.
5. Explain the four basic battery "capacity ratings" systems.
6. List the gases that are produced during the charging process from both the positive and the negative plates.
7. Explain why repeated "overcharging" or "cycling" is harmful to a battery.
8. List the three basic battery tests / inspections that can be performed.
9. List ten (10) items inspected while performing a "visual inspection".
10. Explain the terms "battery drain" and "parasitic loads".
11. Describe the procedure of checking parasitic drain on a car.
12. List the maximum parasitic drain allowed.
13. Describe why and how baking soda is used on an automotive battery.
14. List two methods of checking a battery's "state of charge.
15. List the specific gravity readings of a battery that has the following states of charge: 100%, 50%, 0%.
16. Explain the term "specific gravity" and how it is measured.
17. List the open circuit voltages of a battery with the following states of charge 100%, 50%, 0%.
18. Describe the "open circuit voltage" test procedure.
19. What is the minimum charge a battery needs to perform a Heavy Load Test.
20. Explain in detail the "Heavy Load" or "Capacity" test procedure.
21. What is the maximum time a Heavy Load Test should be performed?

22 How much of a load is placed on a battery that has a 500 CCA rating?

23. What action should be taken if battery voltage drops to 8.7 volts during a heavy load test? What if the voltage was 10.3 volts?